IDENTIFICATION OF TRACE CONTAMINANTS IN SOLID WASTES AND EFFLUENTS FROM SOUR GAS PROCESSING PLANTS AND A METHANOL PLANT

By: Monenco Consultants Pacific Ltd.

For: Environmental Protection Service
Environment Canada

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Any comments concerning its content should be directed to:

Ed Wituschek
Environmental Protection Service
Pacific Region
Kapilano 100 - Park Royal
West Vancouver, B.C.
V7T 1A2

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Monenco Consultants Pacific Ltd.
8th Floor
1199 West Pender Street
Vancouver, British Columbia
V6E 2R1

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PART 1

INTRODUCTION

PART 1 - INTRODUCTION

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1.1 INTRODUCTION

The Environmental Protection Service (EPS) of Environment Canada initiated this study on solid wastes and liquid effluents from three natural gas processing plants and one methanol plant to assemble available information on waste types and characteristics. The study was undertaken with the cooperation of the British Columbia Ministry of Environment, Westcoast Transmission, Petro-Canada and Ocelot Chemicals.

The scope of work for this study is based on the Terms of Reference issued by Supply and Services Canada (file number 52SS.KE145-3-0358) titled "A Study on Identification of Solid Wastes and Effluents and Assessment of Contaminant Removal Feasibility at Natural Gas Plants".

1.1.1 SCOPE OF WORK

The detailed scope of work is as follows:

- To complete a literature and current data review on the characterization, volumes and treatment of solid wastes and liquid effluents from gas processing plants.
- To identify data gaps and develop a sampling and analytical program for solid wastes and liquid effluents at three sour gas processing plants and a methanol plant located in British Columbia.
- To complete a sampling and analytical program of solid wastes and liquid effluents at the selected plants.

- To assess the contaminant removal technologies for solid wastes and liquid effluents including necessary capital and operating costs for alternative technologies to meet varying requirements.

- To assess the implication to toxicity of the current and previously detailed treatment technologies.

- To prepare, as specified, necessary draft and final reports.

1.1.2 OBJECTIVES

The objectives of this report include the following:

- Legislation

A review of the provincial (British Columbia and Alberta) and federal legislation currently regulating gas plant solid and liquid wastes.

- Literature Review

A review of current information on the characterization and treatment of solid and liquid gas plant wastes.

- Existing Environmental Data

A description of the four British Columbia gas processing plants surveyed and a tabulation of the wastes they generate.

- Identification of Data Gaps

Identification of currently unmonitored and/or unregulated wastes.

o Sampling and Analytical Program

Development of a sampling and an analytical program for solid and liquid effluents with emphasis on organic and inorganic contaminants.

o Results of the Sampling and Analytical Program

Methods and results of a preliminary sampling of important process and waste treatment streams and sludges.

o Natural Gas and Natural Gas Processing

A brief description of the constituents of natural gas and the basics of natural gas processing is included in an Appendix to provide background information.

PART 2

LEGISLATION

PART 2 - LEGISLATION

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2.1 GENERAL

The federal and provincial governments have shared authority over matters pertaining to air and water pollution. Traditionally, the federal government has established national standards which are subsequently modified and/or adopted by provincial agencies. Environmental regulations applicable to natural gas processing plants in British Columbia and Alberta are, for the most part, administered by provincial agencies. However, for plants located on federal crown lands or those initiated or funded by federal agencies, federal environmental requirements may predominate.

2.2 BRITISH COLUMBIA

2.2.1 APPLICABLE LEGISLATION

The following Acts are the more prominent pieces of legislation controlling gas processing wastes in British Columbia (Franson 1983, Eco/Log 1983).

2.2.1.1 Environment Management Act

Under the provisions of this Act, the Minister of the Environment participates in research policy development, operation of waste management facilities, public education, and preparation of environmental management plans for specific areas of the Province. One of the more important features is the provision whereby the Minister may call for an environmental impact assessment for a proposed facility.

2.2.1.2 Ministry of Environment Act

This Act establishes the Ministry of the Environment.

2.2.1.3 Waste Management Act

The Waste Management Act is the most important piece of pollution control legislation in British Columbia. In 1982 it replaced the Pollution Control Act and the Litter Act. The Waste Management Act states that either a waste management plan approved by the 'Minister' or a permit issued by a 'Regional Waste Manager' is required before any waste may be introduced to the environment. The conditions of the permit are stipulated by the Regional Waste Manager. It should be noted that waste management plans will only be approved for municipalities. The Act also makes provision for direct participation by the government in the storage, transportation, and disposal of special (i.e. hazardous) wastes.

2.2.1.4 Land Act

The Land Act requires the authority of the Minister of the Environment for disposal of any waste on Crown land.

2.2.2 POLLUTION CONTROL OBJECTIVES

Guidelines for the disposition and quality of solid and liquid wastes from natural gas plants have been published pursuant to the Waste Management Act under the title "Pollution Control Objectives for the Chemical and Petroleum Industries of British Columbia" (B.C. Water Resources Service, 1974). This publication provides guidelines for landfill site-selection and industrial refuse disposal as well as objectives for chemical and petroleum plant waste water quality (see

TABLE 2-1

British Columbia Pollution Control Objectives

Effluent-quality Objectives for Chemical Industries Other Than Petroleum Refineries

	Discharges to Marine Waters			Discharges to Fresh Waters		
	Level A[g]	Level B[h]	Level C[i]	Level A[g]	Level B[h]	Level C[i]
Oil, nonvolatile, mg/L	-	10	15	-	10	15
Oil, total, mg/L	10	-	-	5	-	-
BOD, five-day, 20°C, mg/L	20	45	130	20	45	130
Ammonia, as N, mg/L	10	15	15	10	15	15
Nitrates, as N, mg/L	10	50	50	10	50	50
Total nitrogen, mg/L (kjeldahl)	15	25	25	15	25	25
Chlorate, mg/L	75	150	150	50	100	100
Chloride ion, mg/L (b)	-	-	-	-	-	-
Chlorine, residual, mg/L	0.2	0.5	1.0	0.2	0.5	1.0
Fluoride, mg/L	2.5	10	15	2.5	10	15
Formaldehyde, mg/L	5	5	10	5	5	10
Metals (total)						
Arsenic, trivalent, mg/L	0.05	0.05	0.08	0.05	0.05	0.05
Barium, mg/L	1.0	1.0	1.5	1.0	1.0	1.0
Boron, mg/L	15	15	15	10	10	10
Chromium, mg/L	0.2	0.2	0.2	0.2	0.2	0.2
Copper, mg/L	0.1	0.1	0.1	0.1	0.1	0.1
Lead, mg/L	0.2	0.2	0.2	0.2	0.2	0.2
Mercury, mg/L	0.002	0.050	0.050	0.002	0.050	0.050
Nickel, mg/L	0.2	0.2	0.2	0.2	0.2	0.2
Zinc, mg/L	0.2	0.2	0.3	0.2	0.2	0.2
Phenols, mg/L	0.2	0.3	1.0	0.2	0.3	1.0
Phosphate, as P, mg/L	-	-	-	1.0	10	30
Sulphate, mg/L (b)	-	-	-	-	-	-
Urea, mg/L	2.0	2.0	2.0	1.0	1.0	1.0
Sulphides, mg/L	0.10	0.10	1.0	0.10	0.10	1.0
Cyanide, mg/L	0.10	0.10	0.20	0.10	0.10	0.20
Suspended solids, mg/L (c)	20	20	30	20	20	30
Settleable solids, mg/L (c)	L[j]0.5	L0.5	L0.5	L0.5	L0.5	L0.5
Floatable solids	d	d	d	d	d	d
Total solids, mg/L (e)	3,000	3,000	3,000	1,500	1,500	1,500
Colour, Pt-Co Units at pH 7	20	20	30	15	15	20
Turbidity, JTU	15	15	25	10	10	15
Temperature, °F maximum	90	90	90	90	90	90
pH	6.5-8.5	6.5-9.0	6.5-9.0	6.5-8.5	6.5-8.5	6.5-9.0
Toxicity (f)	50	45	25	100	90	50

a) For discharge of once-through cooling water used for indirect cooling (heat exchangers, bearings, etc.) the maximum permissible oil concentration is 2 mg/L above background

b) While the importance of these characteristics is recognized, no limits have been established at this time

c) Not applicable to discharges to exfiltration ponds

d) Negligible

e) Depends upon the nature of solids other than normal marine composition

f) 96 hour TLm bioassay on salmonid species, expressed as per cent by volume of effluent in receiving-water which is required to give 50 per cent survival over 96 hours.

g) Level 'A' applies to new facilities

h) Level 'B' is an optimum objective for facilities existing prior to 1980

i) Level 'C' a minimum objective for facilities existing prior to 1980

j) L = Less than

Table 2-1). The specific waste management requirements for a particular facility are stipulated by the Regional Waste Manager in the Waste Management Permit for a plant based on site-specific needs of the receiving environment.

The Waste Management Act also includes provision for a manifest system for cradle-to-grave tracking of hazardous wastes.

2.3 ALBERTA

2.3.1 REGULATORY PROCESS

The majority of the natural gas processing plants in Western Canada are located in Alberta. The province has developed comprehensive regulations and procedures to construct and operate the gas plants. Figure 2-1 (CPA 1980) outlines the application procedure to construct and operate a natural gas processing plant in Alberta. The procedure is general in nature and identified permits and licences may not be required for all gas plants.

2.3.2 APPLICABLE LEGISLATION

Legislation in Alberta that may be applied to the management and disposition of solid wastes and liquid effluents from gas plants are summarized in the following paragraphs (Franson 1983, CPA 1980, Monenco Associated Poole 1978):

2.3.2.1 The Department of the Environment Act

This Act establishes the Department of the Environment and outlines the powers and duties of the Minister. It also creates the

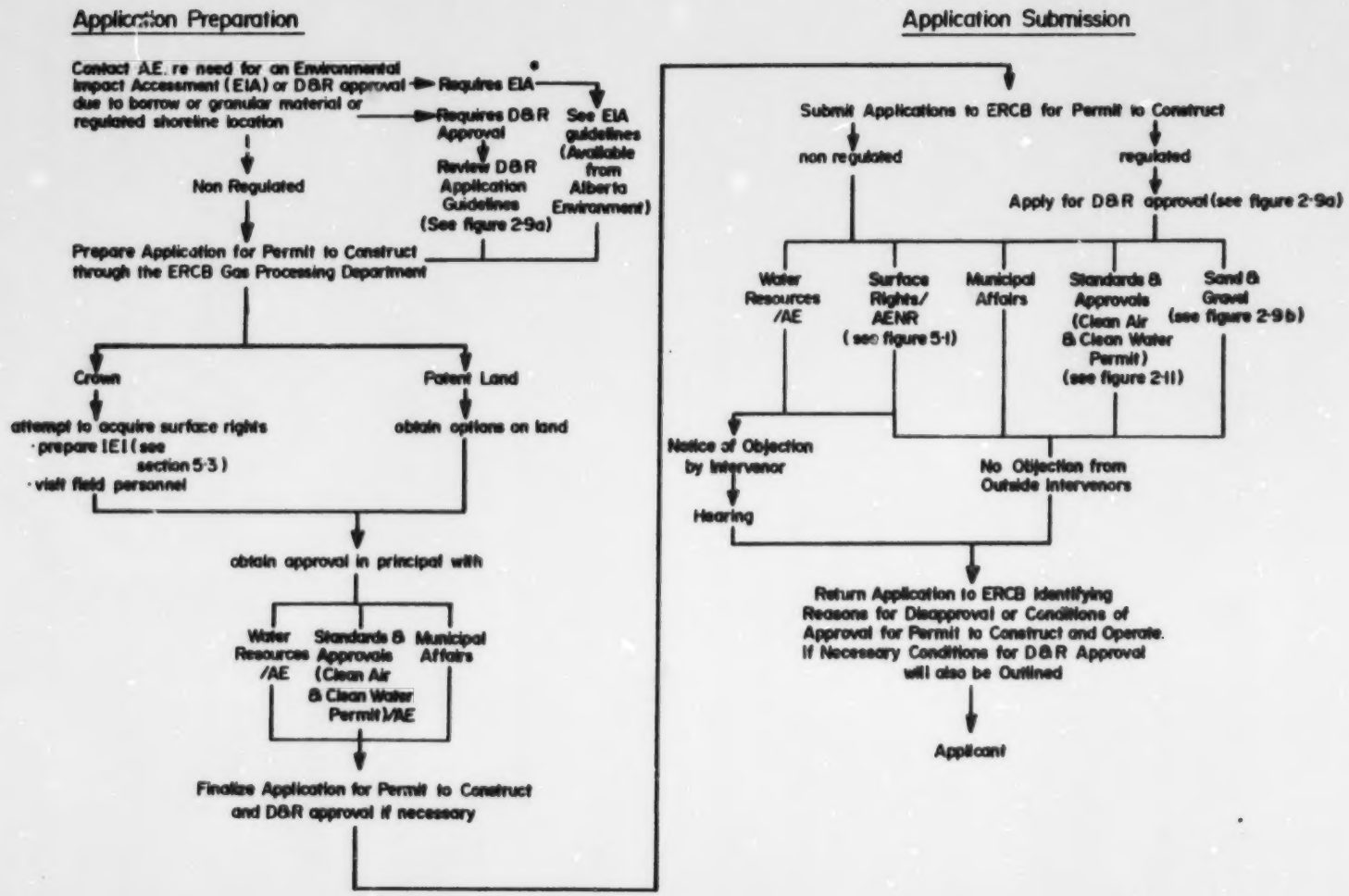
Application Preparation
Application Submission
Contact AE. re need for an Environmental Impact Accessment (EIA) or D&R approval due to borrow or granular material or regulated shoreline location
Requires EIA
Requires D&R Approval
See EIA guidelines (Available from Alberta Environment)
Review D&R Application Guidelines (See figure 2-9a)
Non Regulated
Prepare Application for Permit to Construct through the ERCB Gas Processing Department
Crown
Patent Land
attempt to acquire surface rights
· prepare IEI (see section 5-3)
· visit field personnel
obtain options on land
obtain approval in principal with
Water Resources /AE
Standards & Approvals (Clean Air & Clean Water Permit) /AE
Municipal Affairs
Finalize Application for Permit to Construct and D&R approval if necessary
Submit Applications to ERCB for Permit to Construct
non regulated
regulated
Apply for D&R approval (see figure 2-9a)
Water Resources /AE
Surface Rights/ AENR (see figure 5-1)
Municipal Affairs
Standards & Approvals (Clean Air & Clean Water Permit) (see figure 2-11)
Sand & Gravel (see figure 2-9b)
Notice of Objection by Intervenor
Hearing
No Objection from Outside Intervenors
Return Application to ERCB identifying Reasons for Disapproval or Conditions of Approval for Permit to Construct and Operate. If Necessary Conditions for D&R Approval will also be Outlined
Applicant

Figure 2-1

Application Procedure to Construct and Operate a Gas Plant in Alberta
(reference: Regulatory Permit Services)

• An Environmental Impact Accessment (EIA) can be requested for any size of gas plant but is usually required for sour gas plants of any size and sweet gas plants of 20,000,000 ft^3/day and over.

Natural Resources Coordination Council which is made up of several deputy ministers and exists to review environmental policies, programs, procedures, and services.

2.3.2.2 Land Surface Conservation and Reclamation Act

The Minister of the Environment is charged with the administration of this Act under which referral procedures are provided so that applications can be reviewed by various government departments before decisions are made. One of the most important elements is the Minister's power to require an environmental impact assessment for any proposed production facility. The assessment would evaluate the effects of a project on the conservation, management, and utilization of natural resources as well the effect on the surrounding environment vis-a-vis its aesthetic, wilderness, and recreational value.

2.3.2.3 Oil and Gas Conservation Act

This Act promotes the conservation of oil and gas resources and provides for the control of pollution above, at, or below the ground surface in operations incidental to the production of oil and gas. The Act is administered by the Energy Resources Conservation Board (ERCB).

2.3.2.4 The Clean Water Act

This Act is administered by the Minister of the Environment who has the authority to prescribe maximum permissible concentrations and deposits of water contaminants and methods of determining same. Two standards under the Clean Water Act have particular relevance to the management and discharge of liquid effluents from gas processing facilities. The "Gas Processing Plants Waste Water Management Standards" (Alberta Environment 1973) outline the principal requirements to be implemented by the gas processing industry in accordance with the Clean Water Act. The "Alberta Surface Water Quality Objectives" (Alberta

Environment 1977) define the minimum acceptable ambient water quality for bodies of water receiving gas plant effluents.

2.3.2.5 The Water Resources Act

This Act gives authority and control of all provincial waters to the crown. Therefore, water use by a gas processing plant requires the approval of the Minister of the Environment.

2.3.2.6 The Public Lands Act

This Act, administered by the Department of Energy and Natural Resources, provides for regulations for the disposition of land and the conditioning, maintenance, and reclamation of the surface of public lands.

2.3.2.7 The Hazardous Chemicals Act

This Act allows the Minister of the Environment through the Director of Pollution Control to identify hazardous chemicals and regulate their use, handling, storage, sale, transportation, and disposal by the issuance of Chemical Control Orders (Eco/Log 1983).

2.3.2.8 Special Waste Management Corporation Act

This legislation provides for the establishment of a provincial crown corporation whose mandate is to set up and operate special waste management facilities capable of storing and treating hazardous wastes (Eco/Log 1983).

2.3.3 REGULATIONS

The extent to which the legislation described above regulates solid wastes, liquid wastes and hazardous wastes is described below.

2.3.3.1 Solid Wastes

- o Oil and Gas Conservation Act and Oil and Gas Conservation Regulations:
  - no specific requirements for the handling of solid wastes are sited in the Act but any scheme for management and disposition of wastes requires the approval of the ERCB as a condition of the operating license.
- o The Land Surface Conservation and Reclamation Act:
  - provides regulations for the operation or abandonment of a waste disposal or landfill site (including subsurface disposal of solid waste).
- o Department of the Environment Act (Restricted Development Area Regulations):
  - defines area limits for disposition of waste material.
- o The Public Lands Act:
  - prohibits accumulation of waste material on public land.

2.3.2.2 Liquid Effluents

- o Oil and Gas Conservation Act and Oil and Gas Conservation Regulations:

- regulates the storage and disposition of water produced (i.e. formation water) by a gas plant. Ultimate gathering, storage, and disposal schemes for large volumes of formation water must be approved by the ERCB on any terms or conditions the Board prescribes.

- disposal of process waste water, sanitary waste or surface run-off water is regulated;

  - as above if disposal is to an underground formation is employed.

  - by license issued by the Department of the Environment if disposal is to a body of surface water or disposal pond.

o Clean Water Act:

- the regulations relevant to gas processing plants are outlined in the "Gas Processing Plants Waste Water Management Standards" (1973) issued by Alberta Environment. This publication outlines acceptable waste water management practices and prescribes specific criteria for minimum allowable effluent quality (see Tables 2-2, 2-3 and 2-4). In addition, the "Alberta Surface Water Quality Objectives" (1977) define specific ambient water quality requirements for surface waters receiving gas plant effluents.

o Water Resources Act:

- the diversion of water for use in a gas processing facility is subject to the regulations under the Water Resources Act.

TABLE 2-2

Alberta Gas Processing Plants
Standards of Treated Process Waste Waters
Released from Class C[a] Gas Plants to Watershed Areas

Water Contaminant or Constituent	Emission Rate or Value	Concentration or Value
Chemical Oxygen Demand	1000 lbs/BCF [b]	500 mg/L
Suspended Solids (Total)	100 lbs/BCF	50 mg/L
Sulphide (Total)	1 lb/BCF	0.2 mg/L
Ammonia Nitrogen	50 lbs/BCF	10 mg/L
Oil and Grease	100 lbs/BCF	10 mg/L
Threshold Odor Number	100 units	100 units
pH	6.5-9.5 units	6.5-9.5 units

[a] - Class 'C' plants process sweet or sour gas and discharge waste water to the surrounding watersheds on a continuous basis. Class 'B' plants process sour gas, recover sulphur and do not discharge process waste water to the surrounding watershed.

[b] - lbs/BCF means pounds per one billion cubic feet of raw gas charged to process units based on the reference gas charge rate.

TABLE 2-3

Alberta Gas Processing Plants
Standards of Treated Surface Run-off Water Released From
The Developed Area of Class B[a] and C[b] Gas Plants to Watershed Areas

Water Contaminant or Constituent	Emission Rate or Value[c]	Concentration or Value
Chemical Oxygen Demand	50 lbs/day	50 mg/L
Suspended Solids (Total)	25 lbs/day	25 mg/L
Sulphide (Total)	0.1 lbs/day	0.1 mg/L
Ammonia Nitrogen	5 lbs/day	5 mg/L
Oil and Grease	5 lbs/day	5 mg/L
Threshold Odor Number	50 units	50 units
pH	6.5-9.5 units	6.5-9.5 units

[a] - Class 'B' plants process sweet or sour gas and do not discharge plant waste water to the surrounding watersheds

[b] - Class 'C' plants process sweet or sour gas and discharge waste water to the surrounding watersheds on a continuous basis.

[c] - Based on discharge of 100,000 gallons per day. The emission rate shall be prorated if the design flow rate of surface run-off varies from 100,000 gallons per day.

TABLE 2-4

Alberta Gas Processing Plants
Standards of Toxic Elements

Toxic Elements[a] Total	Concentration mg/L
Arsenic	0.25
Barium	1.0
Cadmium	0.10
Chromium (hexavalent)	0.30
Copper	1.0
Cyanide	0.025
Iron	1.0
Lead	0.10
Manganese	1.0
Mercury	0.0005
Nickel	1.0
Selenium	1.0
Silver	0.10
Vanadium	1.0
Zinc	1.0

[a] The aggregate total toxic element limit of any individual liquid effluent discharged from a Class C gas plant shall not exceed 5 mg/L

- o Land Surface Conservation and Reclamation Act:

  - the commissioning, operation, or abandonment of a facility for subsurface disposal of liquid waste is regulated by this Act.

2.3.3.3 Hazardous Wastes (Solids and Liquids)

- o Clean Air Act and Department of the Environment Act:

  - empowers the Minister of the Environment to issue stop orders regarding practices (including those utilizing hazardous wastes) which may pose a threat to the environment. In addition, the Department of the Environment Act provides for the establishment of regulations controlling any substances detrimental to the environment.

- o Hazardous Chemicals Act:

  - allows the Director of Pollution Control to issue Chemical Control Orders to limit, modify, or stop improper methods of use, handling, storage, sale, transportation, and disposal of hazardous chemicals.

2.4 CANADA

The major piece of federal legislation that has any bearing in effluents from gas processing facilities is the Fisheries Act. The pollution control provisions (Section 33) of the Act are administered jointly by the Department of Fisheries and Oceans and the Department of the Environment. Essentially, the legislation deals with the release of deleterious substances into water frequented by fish. The Act also

contains a provision to request plans and specifications of proponents planning to construct facilities having effluent discharges to waters frequented by fish.

No waste water regulations have been issued purusant to this legislation but the general provisions (Section 33) of the Act apply.

PART 3

LITERATURE REVIEW

PART 3 - LITERATURE REVIEW

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3.1 INTRODUCTION

A literature search was conducted to review information relating to characteristics and volumes of solid wastes and liquid effluents generated by gas plants and various treatment technologies that are presently used in their control. The search revealed a very limited amount of information pertaining to gas plant process wastes. Data on organics including those on the EPA's priority pollutants list and toxic elements was especially sparse. The available information is generally qualitative in nature. Quantitative estimates of concentrations of various contaminants in effluent streams are not available.

Information on treatment technologies is also limited. This was to be expected since most of the waste streams were characterized using conventional parameters (i.e. BOD, COD, oil and grease, etc.) and as such are considered amenable to conventional treatment technologies.

The general lack of information on gas plant processing wastes is contrasted sharply by the large body of qualitative and quantitative data available on petroleum refinery wastes. Some of the wastes (boiler water blowdown, sour water stripper, etc.) generated by refineries are similar to those generated in gas plants and hence these refinery wastes were used to characterize similar gas plant waste streams.

3.2 REVIEW PROCESS

The literature review consisted of a computerized search of a number of Canadian and American data bases supplemented by a manual review of the Monenco library and other in-house publications. The following data bases were incuded in the computerized search.

(1) National Technical Information Service (NTIS)

NTIS is a central source for the distribution of U.S. government sponsored research, development, and engineering reports and analyses prepared by Federal agencies or other special technology groups such as the United States Environmental Protection Agency.

(2) Compendex

The Compendex database covers approximately 3500 journals, publications of engineering societies and organizations, papers from conference proceedings, and selected government books and reports.

(3) Enviroline

Enviroline covers a broad range of environmental issues by indexing periodicals, government documents, industry reports, proceedings of meetings, newspaper articles, films and monographs.

(4) Pollution Abstracts

This database references environmentally related literature on pollution, its sources, and its control.

(5) Elias (Environment Libraries Automated System)

This database is published by Environment Canada and catalogs the holdings from libraries in the Environment Canada Departmental Library Network and Fisheries and Oceans Canada.

3.3 SOLID AND LIQUID WASTE CHARACTERIZATION

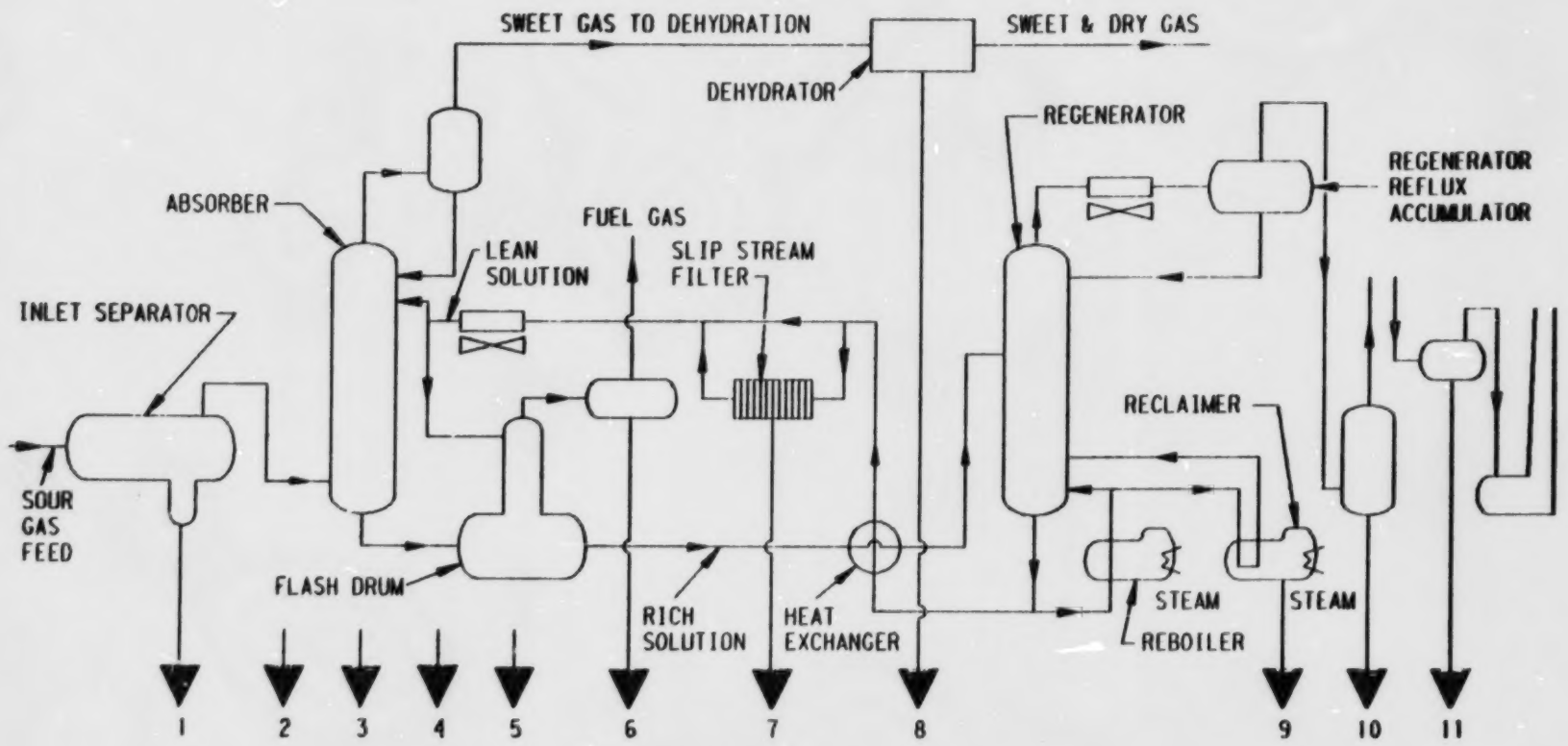
3.3.1 SOUR GAS

3.3.1.1 Liquid Effluents

Figure 3-1 (Zaidi 1976) identifies the sources of the various aqueous waste streams in a typical sour gas processing facility. These and other waste streams are described and characterized in Table 3-1 (CPA 1984, Younger 1983, Ross 1982, Duffy, CPA 1980, Ben Holt Co. 1974, Gloyna 1970). Aqueous wastes commonly encountered in the gas processing industry and the various methods of ultimate disposal for each waste are also identified in the table. The characterization of aqueous wastes originating from a specific plant are qualitatively and quantitatively related to the size of the plant and to the number of unit operations employed (ie, absorption, fractional distillation, cooling, etc.).

3.3.1.2 Disposal and Treatment

Regulatory requirements (Provincial and Federal regulations) and the need for efficient treatment/disposal practices clearly highlight the desirability of segregation of effluents into compatible waste streams. The total effluent from a facility is usually separated into surface runoff, process wastes and sanitary sewage waste streams. In some plants the process wastes are further segregated into compatible streams depending on their relative toxicity, biodegradability, and required treatment. Figures 3-2 to 3-5 (Younger 1983) show four possible and commonly encountered methods for combining waste streams for treatment and/or disposal.



1. Inlet Separator Water
2. Cooling Tower & Boiler Blow Down
3. Shop & Office Floor Washings
4. Wash Rooms Effluent
5. Plant Floor Washings
6. Flash Gas Knock Out Water
7. Filter Washings
8. Dehydration Process Waste Water
9. Reclaimer Drain
10. Sulphur Plant Waste Water
11. Flare Bottle Knock Out Water

FIGURE 3-1

FLOW SHEET FOR A TYPICAL SOUR GAS PLANT AND ITS VARIOUS AQUEOUS WASTE STREAMS

(SOURCE: ZAIDI 1976)

TABLE 3-1

Gas Processing Liquid Effluents

Waste Description and/or Source	Effluent Constituents	Disposal Practices
Boiler Water Blowdown	- chlorides, sulphates, carbonates, silica, sodium phosphates	- pretreatment, downhole injection - treatment, disposal to surface water body - evaporation pond
Cooling Tower Blowdown	- suspended solids, dissolved solids, metal oxides, disperants, chlorine, slimicide, corrosion inhibitors (zinc, chromate, nitrate, molybdate, tungstate, organopolyphosphate)	- pretreatment, downhole injection - ion exchange treatment (for zinc and chromate, other corrosion inhibitors less toxic and not bio-accumulative), disposal to surface water body
Boiler Water Treatment Blowdown	- spent caustic, alum, lime soda softener, calciumm, magnesium, iron phosphates, organics	- treatment, diosposal to evaporation pond - treatment, disposal to surface water body.
Inlet Separator Water (Sour Water)	- sulphides, hydrocarbons, hydrate inhibiting chemicals, salt, oil and grease	- downhole injection - evaporation pond - treatment, disposal to surface water body.
Reclaimer Drain Sludge - a sidestream of the circulating amine solution is routed to a reclaimer which concentrates degradation products into sludge which is then deposited in the reclaimer drain.	- amine based sweetening solution (MEA, DEA, DIPA), sweetening solution degradation products including; o Oxazolidone - 2 o 3-[2-Hydroxyethyl]-oxozolidone-2 o N-[2-Hydroxyethyl]-ethylene diamine o NN'-DI-[2-Hydroxyethyl]-piperazine o 1-[2-Hydroxyethyl]-imidazolidone-2 o DIPA oxozolidone	- pretreatment, downhole injection - pretreatment, incineration - containment in steel drums and disposal at secure landfill
Regenerator Reflux Drain Effluent	- sweetening solution and sweetening solution degradation products	- As per reclaimer drain sludge alternatives

...Cont'd

TABLE 3-1 (Cont'd)

Waste Description and/or Source	Effluent Constituents	Disposal Practices
Flash Gas Knock Out Water	- sweetening solutions	- As per reclaimer drain sludge alternatives
Plant Floor Washings	- hydrocarbons, oil and grease, sweetening solutions, suspended solids, dehydrating solutions (Triethylene glycol, diethylene glycol, ethylene glycol)	- treatment, disposal to surface water body - evaporation pond - pretreatment, downhole injection.
Process Filter Washings	- sweetening solutions and sweetening solution degradation products	- incineration - evaporation pond - pretreatment, downhole injection.
Dehydration Process Water	- hydrocarbons, oil and grease, suspended solids, triethylene glycol (TEG), diethylene glycol (DEG), ethylene glycol (EG), sulphides	- pretreatment, downhole injection - treatment, disposal to surface water body - evaporation pond.
Sulphur Plant Waste Water	- hydrogen sulphide, hydrocarbons, sweetening solution, sulphides	- treatment, disposal to surface water body - pretreatment, downhole injection
Drainage from Sulphur Storage Areas	- low pH, iron, aluminum, sulphates	- treatment, disposal to surface water body - pretreatment, downhole injection
Sanitary Sewage	- biodegradable organics, bacteria	- treatment, disposal to surface water body.
Surface Runoff from Developed Plant Site Area	- suspended solids, dissolved solids, sulphides, ammonia, nitrogen, oil and grease, spilled solutions	- treatment, disposal to surface water body.
Spent or Waste Acids from; - sour water steam stripping facilities - acid cleaning of equipment	- hydrochloric acid, sulphuric acid, sulphamic acid	- pretreatment, downhole injection - neutralization, treatment, disposal to surface water body.

...Cont'd

TABLE 3-1 (Cont'd)

Waste Description and/or Source	Effluent Constituents	Disposal Practices
Caustic Washes (aqueous sodium hydroxide solution for gas sweetening)	- sulphides, mercaptans, phenols, thiophenols, organic acids; all in the form of sodium salts	- pretreatment, downhole injection - evaporation pond - treatment, disposal to surface water body
Used Lubricating Oils (from process equipment lubrication)	- oil, heavy metals, process contaminants	- shipment to waste lube oil recycling centre - incineration
Sour Water Stripper Bottoms	- sulphides, ammonia, chloride phenols,	- treatment, disposal to evaporation pond - treatment, disposal to surface water body
Spent or Waste Liquid Catalyst from IFP Tail Gas Clean-Up Process	- polyethylene glycol containing a metal salt catalyst	- pretreatment, downhole injection - pretreatment, incineration - containment in steel drums and disposal at secure landfill

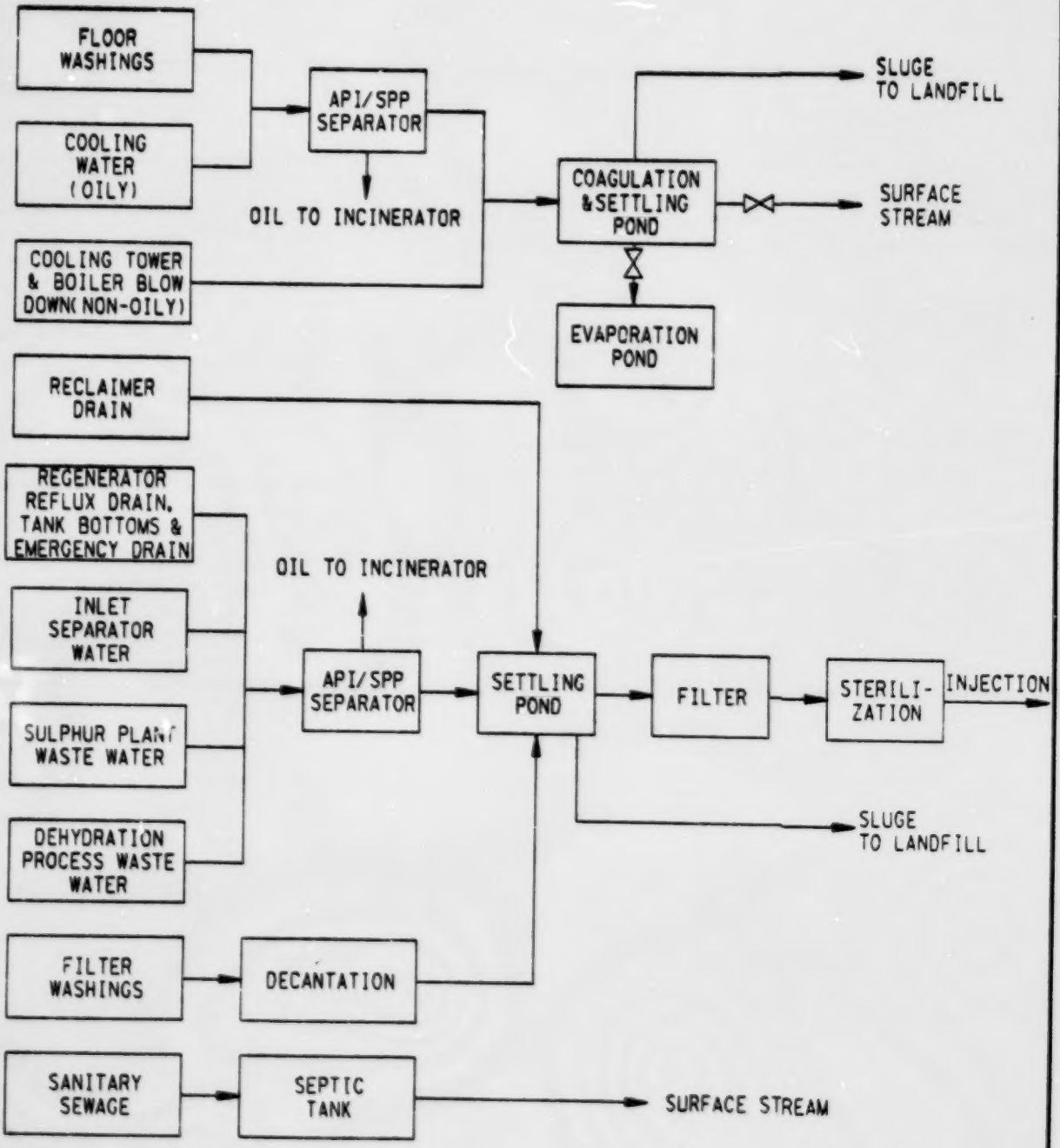


FIGURE 3-2
SEGREGATION AND DISPOSAL SYSTEM 1

(SOURCE: YOUNGER 1983)

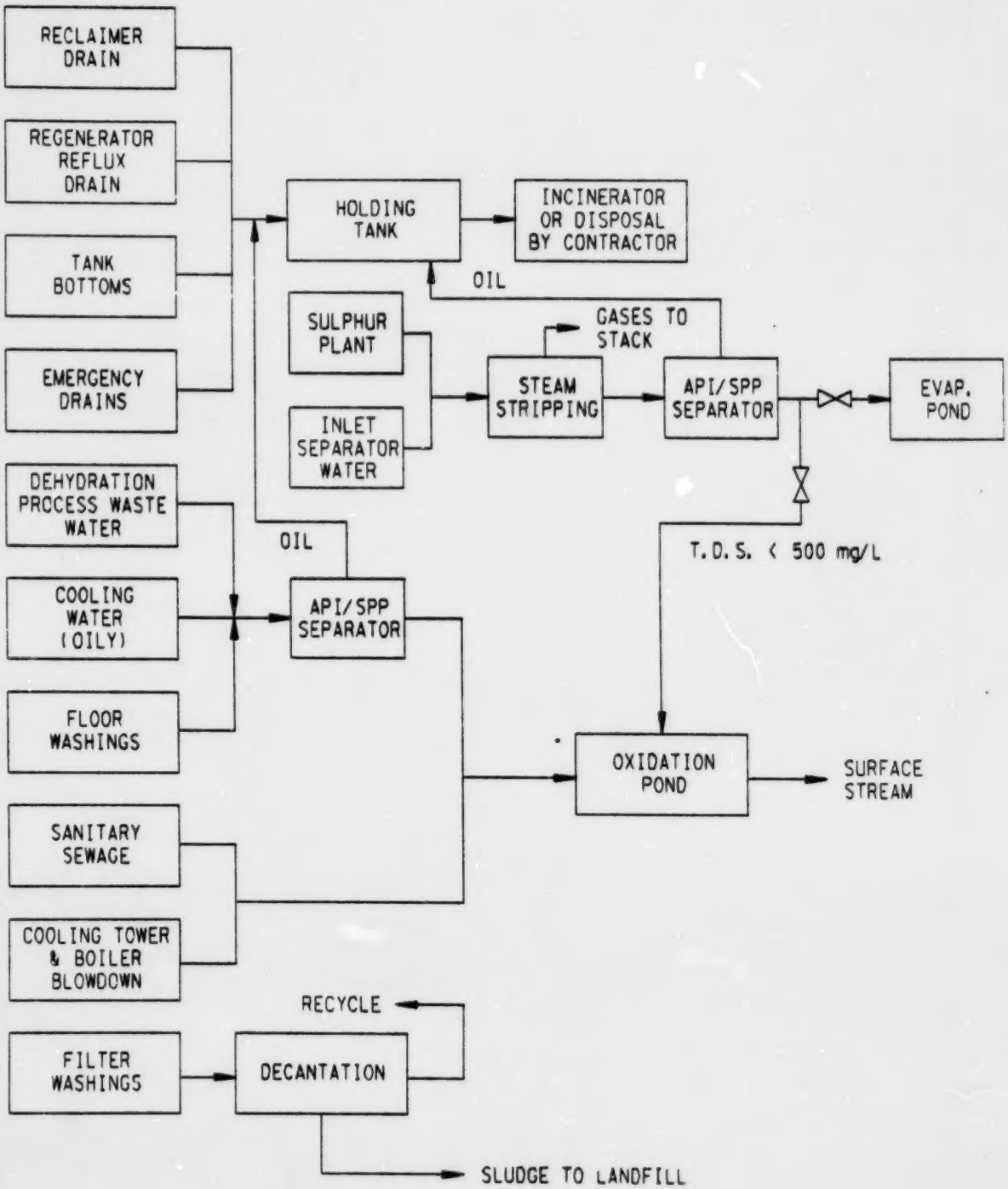


FIGURE 3-3
SEGREGATION AND DISPOSAL SYSTEM 2

(SOURCE: YOUNGER 1983)

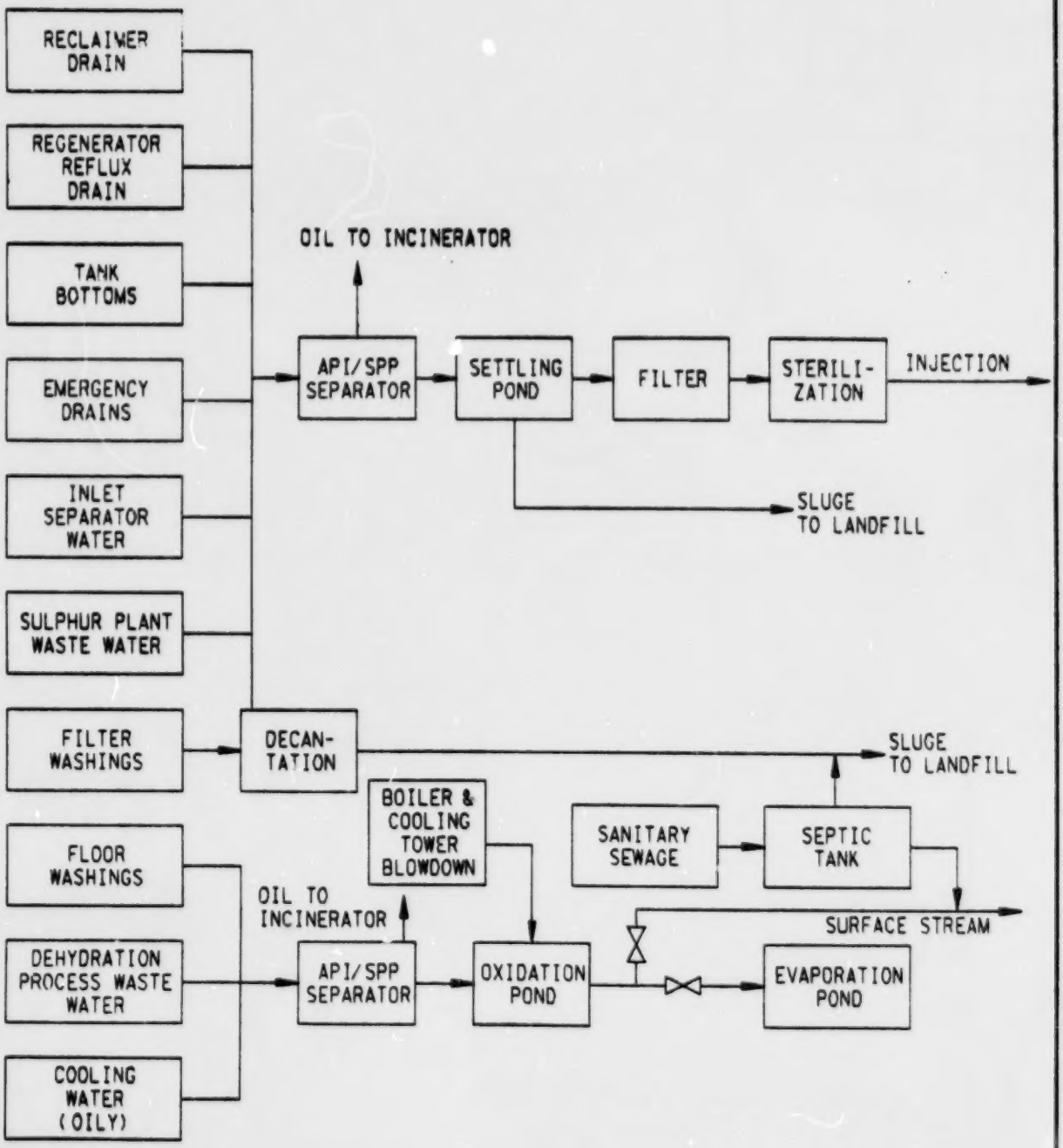


FIGURE 3-4
SEGREGATION AND DISPOSAL SYSTEM 3

(SOURCE: YOUNGER 1983)

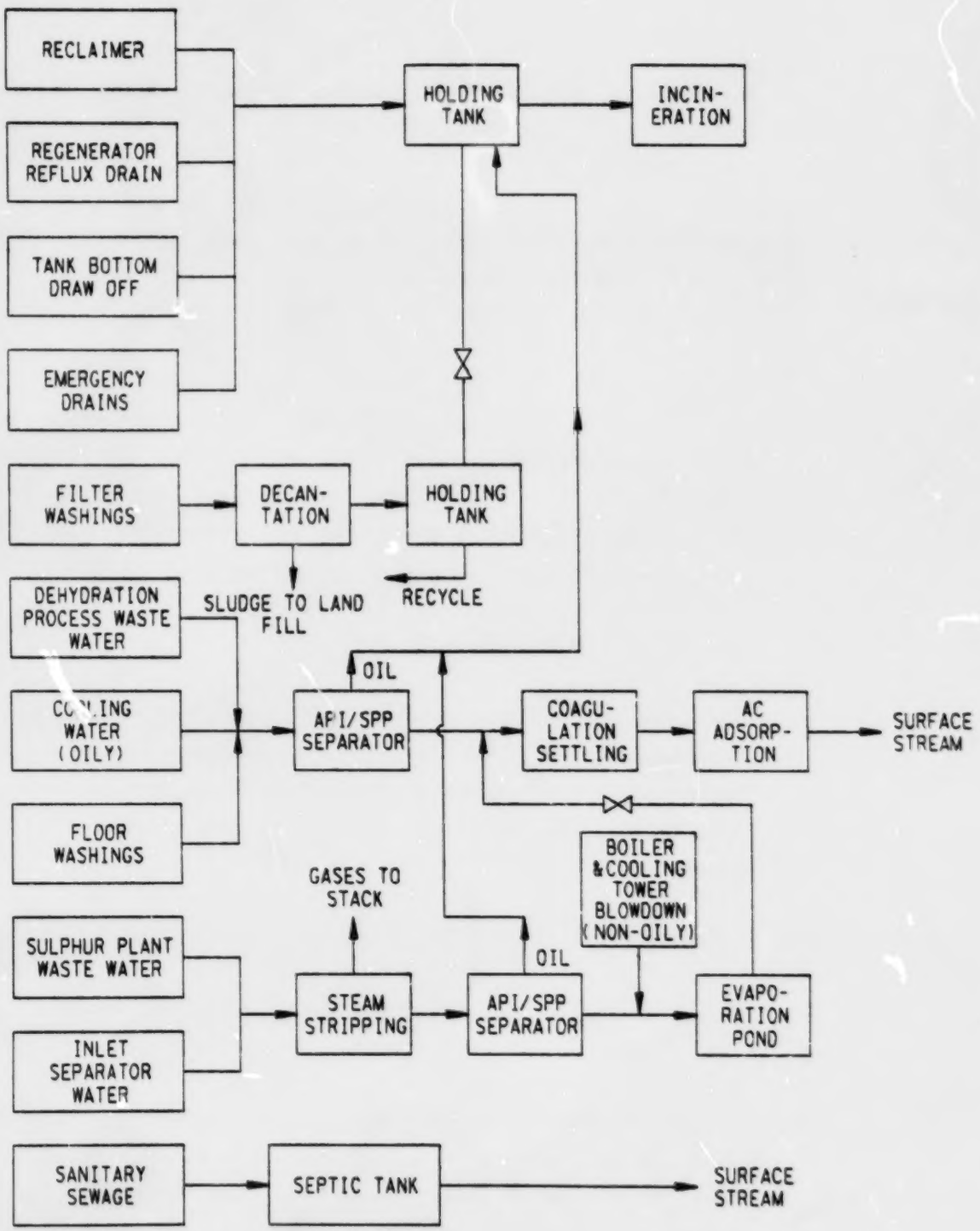


FIGURE 3-5
SEGREGATION AND DISPOSAL SYSTEM 4

(SOURCE: YOUNGER 1983)

Reference is made in the Figures and Tables to various methods of waste treatment and disposal. The following commentary provides details of these methods.

3.1.1.21 Disposal There are four methods of aqueous waste disposal commonly encountered in gas processing facilities:

- o Evaporation

  Where effluent discharge volumes are small, disposal by complete evaporation in an impermeable holding pond may be feasible. The settleable components of the waste will accumulate and eventually the resulting sludge will have to be disposed of (see solid wastes section).

- o Release to Surface Waterbody

  For waste streams that cannot easily be recycled or eliminated, treatment is usually required prior to discharge to any surface water body. The required surface water discharge criteria are defined by the relevant legislation and plant operating permits.

- o Subsurface Injection

  Subsurface (downhole) injection is a process by which wastes are deposited in underground formations, usually spent hydrocarbon formations. It is a form of storage rather than treatment and can be advantageous in situations involving wastes which would be costly to treat for surface disposal. In many jurisdictions there are few if any chemical parameter limits on injected wastes making this disposal method particularly attractive for difficult-to-treat wastes in the

vicinity of a suitable underground formation. However, this form of disposal raises a number of concerns:

- the potential for fresh water contamination through well failure, geological faults, or unknown abandoned wells;
- the long-term adverse geological impact of injection;
- the impact of chemical incompatibility of injected waste on the receiving formation;
- the effects of subsurface pressure changes; and
- inability to correct adverse effects caused by subsurface injection.

It has been suggested (Milne 1973) that the potential for deleterious effects from downhole injection can be reduced if the wastes are pretreated as follows:

- settling to remove large particulate matter;
- filtering through diatomaceous earth to remove suspended solids; and
- elimination of bacteria by sterilization.

o Irrigation

Some of the less toxic effluents are disposed of by spray irrigation on land. This method is usually employed in conjunction with some form of pretreatment (ie. initial detention in holding pond to remove settleable particulates). This dis-

posal method is not widely used in the gas processing industry and would only be used for low volume effluents with few toxic organics or heavy metals.

3.3.1.22 Treatment Treatment of waste waters referred to in the tables or shown on the figures include one or more of the following components:

- o API/SPP separators

  API Separators and Shell Parallel Plate (SPP) Separators are used to remove oil and grease from aqueous waste streams. Inlet separator water, dehydration process waste water and floor washings are the most significant oily waste streams. Both of these separators make use of differences in specific gravity to separate the immiscible oil phase from the aqueous phase. Oil is collected from the top of the separator and is directed to the oily sludge disposal facility, usually an incinerator.

- o Coagulation/Flocculation Ponds

  Suspended solids from floor washings, cooling tower and boiler blowdown, water treatment backwash, and dry desiccant dehydration waste water must be removed prior to disposal to a surface water body. This is normally accomplished by adding coagulants (alum, lime, etc.) and/or flocculants (polyelectrolytes) to the effluent. The coagulated particulates form a floc which then settles to the bottom of the pond. The accumulated sludge eventually reduces the capacity of the pond and must be removed from time to time.

- Oxidation Ponds

Oxidation ponds reduce phenol and BOD levels by means of bacteria which have been acclimatized to the organic food matter available. The organic matter is oxidized to carbon dioxide and water in the process. In aerated ponds, oxygen is maintained at levels of 1-2 ppm by mechanical aeration.

- Filters

High rate (500-1000 $L/m^2/min$) filtration through various media, usually sand, is capable of removing suspended solids down to a few microns in size. The filters serve mainly as polishing devices and are regenerated by backwashing when the pressure drop through the media reaches a predetermined level.

Diatomaceous earth filters are also used to remove suspended particulates. They consist of a layer of diatomaceous earth about 3 mm thick supported on a septum or filter element. This thin layer is subject to cracking and hence must be continuously supplemented by a body feed of diatomaceous earth in the raw water. When the pressure drop over the septum reaches its economic limit the spent diatomaceous filter cake is removed by backwashing.

- Activated Carbon Adsorption

Activated carbon adsorption is used to remove relatively low levels of organic contaminants from gas processing waste waters. It is normally used as one of the final steps in the waste water treatment process, immediately prior to disposal to a surface water body. Waste streams with high levels of

organics (phenols, glycols, sweetening products, sweetening degradation products) are usually more economically disposed of by incineration (Younger 1983).

- o Steam Stripping (Sour Water Strippers)

Steam stripping is used to remove sulphides and ammonia, the major source of which is the sulphur plant waste water. The sour water is introduced at the top of a packed or trayed tower while the steam is introduced at the bottom. Sour gas is stripped from the water and exits from the top of the tower. Typically these strippers remove 99 percent of the sulphides, 80-95 percent of the ammonia, and 30-60 percent of any phenols present (James 1976).

- o Incineration

Liquid effluent incineration is discussed in Section 331.43.

The following treatment systems, while not specifically referred to in the tables or figures are often encountered in gas plant waste water effluent treatment facilities.

- o Activated Sludge

Activated sludge systems aerobically decompose biodegradable organic waste waters into carbon dioxide, water and sludge.

To accomplish this, micro-organisms (bacteria) are introduced to the organic waste water in an aeration tank in which oxygen and mixing are provided by air diffusers. The bacteria consume organic matter and form a visible mass of suspended, flocculated solids referred to as 'activated sludge'. The effluent is then passed to a clarifier where the activated sludge is

settled from the 'aerated mixed liquor' under quiescent conditions. Clear supernatant is discharged from the top of the clarifier while some of the settled activated sludge is recycled to the head of the aeration tank.

In this process, wastes are biologically oxidized by the aerated activated sludge and chemically oxidized by aeration.

3.3.1.3 Solid Wastes

Table 3-2 (CPA 1984, Younger 1983, Alberta Environment 1983, Ross 1982, Duffy, CPA 1980) identifies and describes the various sources of solid waste in a gas processing facility. Again, not all the sources identified would be present in all plants. The volume of waste generated is a function of the size of the plant and the number and type of processes employed.

3.3.1.4 Disposal and Treatment

There are three basic methods of treating and/or disposing of solid wastes.

3.3.1.41 Landfilling Landfilling is probably the most commonly practiced method of solid and semi-solid (eg. sludges) waste disposal in the gas processing industry. Generally wastes are segregated into compatible groups prior to disposal in any landfill. The groupings are established on the basis of the waste characteristics (toxic, organic, metals, acids) and the required treatment practices (eg. neutralization, oxidation, decomposition). To this end, there are various types of landfills designed to accommodate each waste category.

TABLE 3-2

Gas Processing Solid Wastes

Waste Description and/or Source	Waste Constituents	Disposal Practices
Holding and Evaporation Pond Sludges - the waste make-up of a particular sludge is a function of the type and number of waste streams entering the pond. Waste streams are normally combined into compatible groups and distributed to separate ponds.	- the large number of possible effluent treatment processes means that virtually any combination of the effluent constituents noted in Table 3-1 could be found in any one holding pond sludge.	- unless the sludge constituents can be predicted accurately from an analysis of the past and present incoming waste streams, a sampling analysis for a broad spectrum of organics, metals and other substances should be made. Depending on the result of this study, a decision vis-a-vis disposal can be made. The two most commonly employed methods of disposal are: o secure landfilling o landfarming
Oil Sludge from API/SPP Separator	- waste hydrocarbons, phenols, possibly heavy metals	- incineration - landfarming
Process Filters - virtually all of the basic components of a gas processing facility use filters which are replaced and discarded from time to time. The wastes consist of the filters themselves and residual amounts of the liquid used in the process from which the filter came.	- Glycol Filters o corrosion products; iron sulphides and iron oxides o degradation products, mild acid, carbon, higher glycols o possible upstream contaminants; sulfinol, produced water o filming amines o 3-phase inhibitor - Amine/Sulfinol Filters o amine degradation products o iron sulphide scale o chlorides - Domestic Water Filters o inorganic and organic solids	- drain filters - route fluids to appropriate treatment/disposal facility - dry filters should be: o incinerated o sealed and buried in secure landfill

...Cont'd

TABLE 3-2 (Cont'd)

Waste Description and/or Source	Waste Constituents	Disposal Practices
Process Filters (Cont'd)	- Produced Water Filters o inorganic solids o bacteria o oil o iron sulphides - Chemical Filters o chemical present - Lube Oil Filters o filming inhibitor o amines o acid - Diatomaceous Earth Filters o suspended solids o sweetening solution o sweetening solution degradation products - Activated Carbon Filters o organics, i.e., trace levels of sweetening solution and sweetening solution degradation products, glycols, phenols	
Spent Lime Slurry from Boiler Feedwater Treatment	- calcium, magnesium, iron, hydroxides, silt, organic matter	- landfill - landfarming
Spent Iron Sponge	- wood shavings, ferric sulphide, acid (may be formed when sponge is oxidized after disposal; acid can dissolve and mobilize heavy metals)	- landfilling with lime - landspreading with lime

...Cont'd

TABLE 3-2 (Cont'd)

Waste Description and/or Source	Waste Constituents	Disposal Practices
Dehydration Process Dry Desiccants	- molecular sieves (sodium aluminasilicate), silica gels, alumina, silica - alumina beads, synthetic zeolite, desiccant contaminants (oil, glycol, heavy hydrocarbons)	- landfill o uncontaminated desiccants only - seal in drums, disposal at secure landfill o contaminated desiccants
Spent Catalysts from Sulphur Conversion Process	- activated alumina, activated bauxite, cobalt molybdenum, vanadium oxide, lanthanum oxide, titanium dioxide, catalyst contaminants (sulphur, sulphates, carbon, diethanolamine)	- catalyst should be regenerated immediately before disposal to minimize level of catalyst contaminants. - recycle to vendor (except activated bauxite or alumina) - landfill o uncontaminated catalyst - landfill with lime o contaminated catalyst
Spent Catalysts from Tail Gas Clean Up Process	- Sulfreen Process o activated alumina - Amoco CBA Process o activated alumina - The SCOT Process o cobalt molybdenum - The Beavon Process o cobalt molybdate	- as per sulphur conversion alternatives
Waste Sulphur	- Sulphur contaminated with soil - Soil contaminated with sulphur (sulphur dust); soil will be affected as follows: o low pH o loss of base cations, calcium, magnesium, potassium, sodium o mobilization/dissolution of aluminum, manganese, and iron	- landfill with lime o areas in and adjacent to the sulphur storage area should be treated with limestone - landfarming with lime

...Cont'd

TABLE 3-2 (Cont'd)

Waste Description and/or Source	Waste Constituents	Disposal Practices
LPG Storage Tank Bottoms	- tank scale, residue LPG, upstream process contaminants, some heavy metals	- incineration - secure landfill - landfarming o if metals concentration not too high - pretreatment, downhole injection
Chemical Barrels	- chemical residue	- return to vendor - clean and reuse o innocuous chemicals only - landfill
Incinerator Ash	- inert solids, fluid bed material, metals	- secure landfill
Inert Trash	- general garbage	- incineration - landfill
Scrap Metal and/or Equipment	- scrap process components may be contaminated with residual amounts of process fluids - scrap electrical equipment may contain Polychlorinated Biphenyls (PCBs)	- determine extent of contamination - uncontaminated material o landfill - materials contaminated with significant levels of toxic process fluids o secure landfill - material contaminated with PCBs o secure storage until PCB destruction facility is available

- **Secure landfill**

  A specially designed landfill for containment of wastes with controls to virtually eliminate the possibility of ground or surface water contamination under any foreseeable circumstance. Usually, a secure landfill is equipped with leachate monitoring and collection provisions. This type of facility may be capable of receiving all manner of toxic and/or hazardous wastes (eg. contaminated process filters, chemical barrels, and sludges with high metals content). It is usually not feasible for a gas processing plant to have a secure landfill on-site. At present there are no secure landfill sites in British Columbia. Hazardous materials must be transported to the nearest secure facility.

- Sanitary landfill

  Sanitary landfills are used for the disposal of most municipal solid wastes and are common at gas processing plants and other industrial facilities. The landfill is designed employing natural soils and/or impermeable barriers to minimize the possibility of ground or surface water contamination. A sanitary landfill is usually considered suitable for certain wastes which do not pose significant concerns in the long-term (eg. sewage and water treatment sludges, uncontaminated catalysts and dry desiccants).

- Process waste landfill

  Some gas plant processes generate wastes which are relatively innocuous and require specific amendments (usually pH adjustments) that are most economically applied at the plant site. A pit is excavated in impermeable soil to a depth of 1 to 2 metres above the water table. The waste is deposited and

lime or limestone is added to provide buffering capacity. Spent iron sponge, uncontaminated molecular sieves and catalysts, and sulphur-contaminated soils are often disposed of in this manner.

3.3.1.42 Landfarming Landfarming or landspreading is the repeated application of oily sludge to soil and the promotion of microbial growth which converts hydrocarbons to carbon dioxide and water and increases the humus content of the soil (Grove 1978). It is suitable for most oily sludges from a gas processing facility (eg. API/SPP separator sludge, tank bottoms).

A site is selected near the plant site and is dedicated for landfarming use only. The accumulation of heavy metals over time may preclude the use of such land for future agricultural use. The area must be provided with a surface runoff collection system which directs runoff to the plant waste water treatment system.

The sludge is usually applied by truck to a depth of 25 to 50 mm depending on the climate and the assimilative capacities of the soil (Jacobs Engineering 1976). Farm type disc aerators are then used to break up the oily crust, mix it with the surface layer of soil, and provide areation. Lime is occasionally added to keep the pH above 6.5 which maintains the metals as precipitates and hence minimizes metals content in surface runoff. Nitrogen fertilizer is also added to increase bacterial growth and enable more sludge to be applied to the soil (Grove 1978).

A number of other more innocuous wastes may also be candidates for landspreading. Spent boiler feedwater lime slurries, spent iron sponge, and sulphur contaminated soil can also be disposed of in facilities similar to those described. Lime is added to these wastes during the spreading operation to maintain an acceptable pH level in the soil.

3.3.1.43 Incineration Incineration is a process which thermally oxidizes waste into carbon dioxide, water, and ash. It provides the advantages of waste volume reduction, elimination of harmful bacterial and viral constituents and destruction of organic compounds (sweetening agents and degredation products, glycols, phenols), and provides the opportunity for waste heat recovery. A wide variety of solid and liquid wastes are candidates for incineration including oily sludges, process filters, general trash, high strength aqueous organic waste streams, and organic sludges. There are a number of incineration devices in use, each one with particular advantages for a specific waste. In each case the efficiency of the combustion (ie. oxidation) process is a function of waste combustibility, residence time, flame temperature, and turbulence in the reaction zone (Hitchcock 1979).

3.3.2 SWEET GAS

The only processing facilities required for sweet gas are those associated with dewpoint control and LPG recovery. Clearly the volumes of waste generated by such plants are considerably less than those associated with a sour gas plant requiring sweetening and sulphur recovery. Tables 3-1 and 3-2 are applicable to sweet gas processing facilities if the following wastes are deleted:

- Liquid Effluents
  - reclaimer drain sludge
  - regenerator reflux drain
  - flash gas knockout water
  - sweetening solution filter washings
  - sulphur plant waste water
  - caustic washes (for H_2S removal)
  - drainage from sulphur storage areas
  - tail gas clean-up catalysts

o **Solid Wastes**

- amine/sulfinol filters
- spent iron sponge
- spent sulphur recovery catalysts
- waste sulphur
- spent tail gas clean-up catalysts

3.3.3 QUANTITIES AND CONCENTRATIONS

As discussed previously, there is very little information available in the literature on solid and liquid wastes from gas processing facilities. Information on solid waste volumes in particular is very limited. Table 3-3 (Younger 1983) provides estimated flow rates for some of the more common aqueous waste streams in a hypothetical gas processing facility. Quantities of wastes generated is plant specific; hence, the flow rates presented in Table 3-3 should be viewed as estimates only.

Monenco has recently been involved in a decommissioning study for a 26 year old Gulf Canada sour gas plant at Pincher Creek, Alberta. The study was initiated to define the extent of contamination and to develop clean-up and reclamation plans. The plant in question originally produced almost 7 million m^3/d of sales gas. It employed most of the processes commonly encountered in gas plants, namely; liquids separation, sweetening (MEA and DEA solvents), dewpoint control, LPG recovery and processing, and sulphur recovery.

During the study, detailed sampling and testing was carried out to characterize and quantify contamination in soils, surface drainage way sediments, and building drain sludges. Table 3-4 lists the contaminants that were encountered in soil samples taken from various process areas and gives the concentration range of these contaminants. Selected

TABLE 3-3

Estimated Flow Rates of Some Aqueous
Waste Streams for a Hypothetical Sour Gas Plant[a]

Waste Stream Description	Flow Rate Litres/day
Inlet Separator Water	25000
Cooling Tower and Boiler Blow Down	8000 - 570,000[b]
Plant and Office Floor Washings	6000
Washrooms Effluent	2000
Filter Washings	11000
Dehydration Process Water	8000
Reclaimer Drain	200
Sulphur Plant Waste Water	3000

[a] 4.2×10^6 m^3/d Sour Gas Feed Containing 5% H_2S (Younger, 1983)

[b] Monenco Engineers & Constructors Inc. 1983. Investment and Operating Cost Study, Sulphur Recovery Facilities, Natural Gas Processing Industry for Environment Canada, 1983.

TABLE 3-4

Summary of Contaminants Found in Soils from
Gulf's Pincher Creek
Sour Gas Plant, Alberta

Process Area	Contaminant	Concentration Range (ppm)
Boilerhouse (process steam generation)	Chromium	34 to 150
	Cadmium	0.2 to 1.5
	Zinc	276 to 670
	Mercury	0.18 to 6.8
Cooling Tower	Chromium	34 to 423
	Zinc	276 to 382
Sweetening Plant	Chromium	30 to 243
	Mercury	0.18 to 5.0
	Ammonia	23 to 378
	Total Kjeldahl Nitrogen (TKN)	429 to 2042
	Nitrates	1.7 to 660
Inlet Separation and Dewpoint Control Facilities	Chromium	34 to 55
	Mercury	0.25 to 1.28
	Hydrocarbons	0.02% to 0.04%
LPG Recovery and Processing Plant	Cadmium	0.2 to 4.0
	Chromium	34 to 91
	Mercury	0.18 to 2.7
	Hydrocarbons	0.02% to 1.50%
LPG Storage Area	Hydrocarbons	0.8% to 2.4%
Sulphur Plant	Sulphur	0.15% to 12.5%
	Cadmium	0.2 to 2.4
	Zinc	82 to 1225
Sulphur Block (ie. elemental sulphur storage)	Sulphur	0.15% to 22.5%
	Sulphate	up to 31 900
	pH	1.0 to 7.9

samples, normally those with hydrocarbon contamination, were subjected to gas chromatography/mass spectrometry (GC/MS) analyses to identify organic compounds. The results of the analysis are summarized in Table 3-5. Again, the level of contamination is site specific and Tables 3-4 and 3-5 should be used only as an indicator of potential contaminants (trace elements, organics and other pollutants) which may be generated in a gas processing facility.

TABLE 3-5

Results of Organic Analysis (GC/MS) for Samples from
Gulf's Pincher Creek Sour Gas Plant, Alberta

Location	Polycyclic Aromatic Hydrocarbons (ppm)	Nitrogen Substituted Aromatic Hydrocarbons (ppm)	Substituted Benzenes (ppm)	Thiophenes (ppm)	Phthalates (ppm)	Polychlorinated Biphenyls (ppm)	Diethanolamines (DEA) (%)	Others[a] (ppm)
Soils								
Near amine storage tank	3	-	-	-	15	-	-	232
Near amine sump	3.2	-	-	-	-	-	-	337
Near LPG Recovery Building	1310	17	-	-	5	-	-	5890
Adjacent to Inlet Separator Building	50	-	-	-	-	-	-	150
Near LPG load-out	328	-	1850	-	-	-	-	10520
Drainage Way Sediments								
North Side of Sweetening Plant	11	-	-	-	-	-	-	6889
West Side of Inlet Separator Building	10100	25	210	1140	37	1.0	-	6730
In-Building Sludges								
Sweetening Plant - amine sump	-	-	-	-	-	-	80	8000
Sweetening Plant - gutter	840	-	-	170	-	1.5	-	790
LPG Recovery Building - gutter	16300	-	-	8800	-	1.4	-	82880

[a] Others include Paraffins/Olefins and/or Alcohols/Cyclic Paraffins.

PART 4

GAS PLANT SURVEY

PART 4 - GAS PLANT SURVEY

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4.1 INTRODUCTION

Information on waste generation and treatment/disposal practices at the sour gas plants and the methanol plant is presented in this section. Specific plants to be surveyed were selected by Environment Canada and included:

- Fort Nelson Gas Plant (Westcoast Transmission)
- Pine River Gas Plant (Westcoast Transmission)
- Taylor Refinery and Gas Plant (Westcoast Transmission and Petro-Canada)
- Kitimat Methanol Plant (Ocelot Chemicals)

In addition to information obtained from the operators of the facilities, waste management information was also obtained from Environment Canada and the British Columbia Ministry of the Environment.

The following sections provide a brief description of plant processes, identify major solid and liquid waste streams, and describe waste treatment and disposal facilities for each of the selected plants.

4.2 WESTCOAST TRANSMISSION-FORT NELSON PLANT

4.2.1 PLANT DESCRIPTION

The Fort Nelson gas processing plant is operated by Westcoast Transmission Co. Ltd. and is located approximately 25 km south of the town of Fort Nelson, British Columbia. It produces a maximum of about 22000 x 10^3 cubic metres of sales gas per day from a raw gas stream containing 2 to 4 percent H_2S and 12 percent CO_2. The original plant was

completed in 1965 and, in 1974, additional sulphur recovery facilities and a waste water treatment plant were added.

4.2.2 PROCESS DESCRIPTION

The facilities at the Fort Nelson plant consist of eight trains for sweetening and dehydrating raw gas. Four of these trains use hot potassium carbonate with MEA clean-up while the other four use DEA as the solvent for gas sweetening. At the present time, only two of the four hot potassium carbonate trains are in operation. Silica gel adsorbants are used in all trains for sales gas dehydration. There are no LPG recovery facilities at this plant.

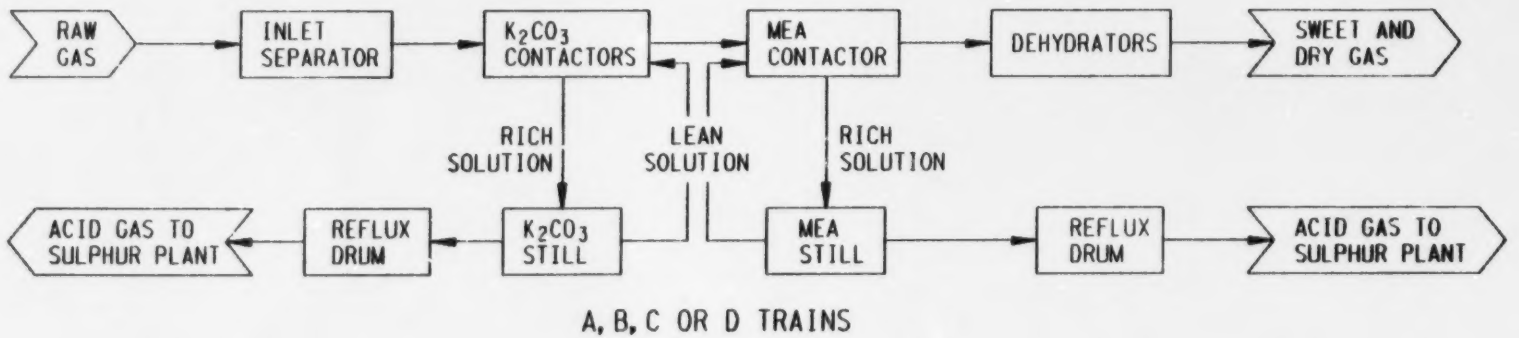
The sulphur plant converts H_2S to elemental sulphur using a double-train Modified Claus process and a Sulfreen tail gas clean-up unit. The overall sulphur recovery efficiency for this plant is 95 percent. Approximately 250 tonnes per day of elemental sulphur is produced at a raw gas H_2S concentration of about 2 percent. Elemental sulphur is then delivered to Petrosul International Ltd. for pelletizing and marketing.

Process flow diagrams for the Fort Nelson facility are presented in Figures 4-1 and 4-2.

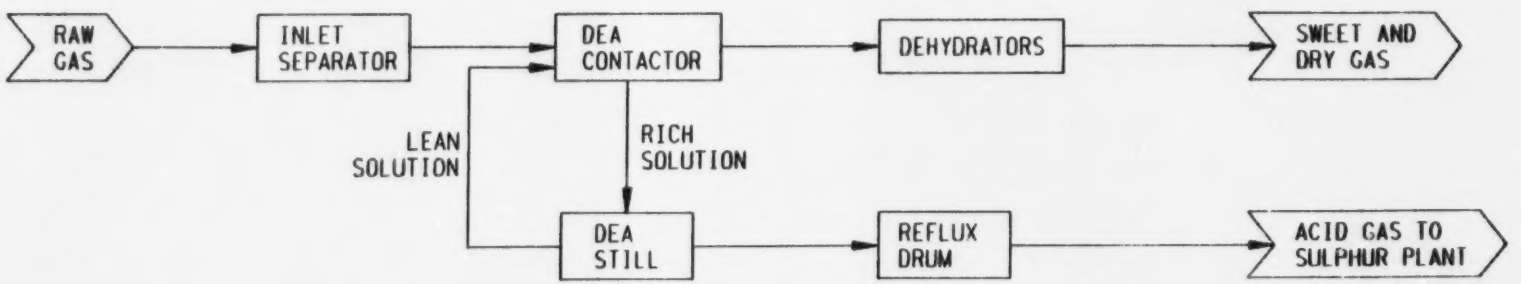
4.2.3 WASTE HANDLING PROCESSES

4.2.3.1 Solid Wastes

Most solid wastes (including sludges) are disposed of in one of a number of landfills located on the plant site. Separate sites are provided for scrap metal, spent catalysts and desiccants, and holding pond sludges (primarily those for lime sludge from boiler feedwater



A, B, C OR D TRAINS



E, F, G OR H TRAINS

FIGURE 4-1
FORT NELSON GAS PLANT
GAS PROCESSING FLOW DIAGRAM

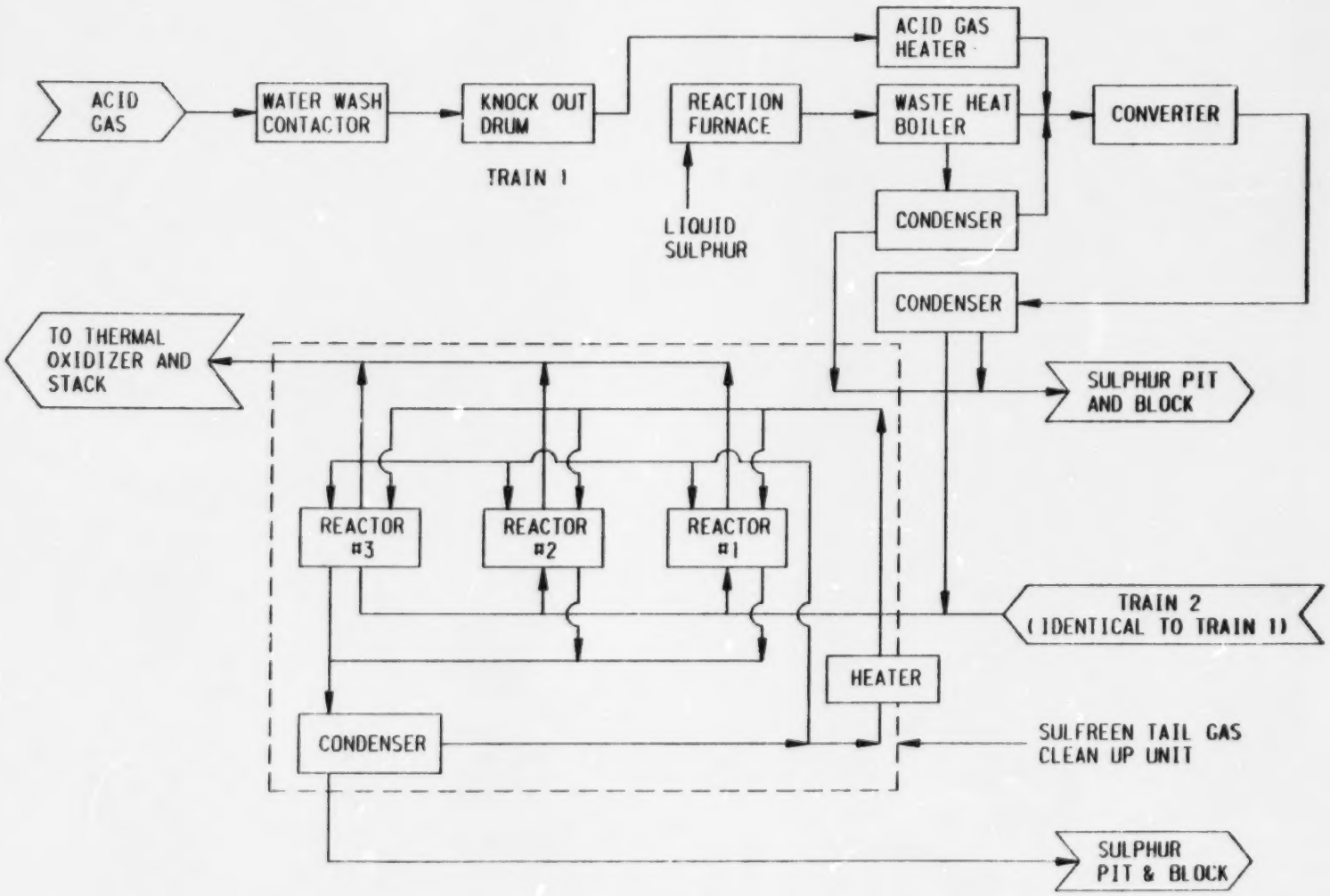


FIGURE 4-2

FORT NELSON GAS PLANT

SULPHUR RECOVERY FLOW DIAGRAM

treatment). No treatment is applied to solid wastes disposed of in these pits. In addition, two storage areas are provided for reclaimable scrap metal, domestic garbage and dunnage. Domestic garbage and dunnage are periodically hauled to the Fort Nelson municipal landfill for disposal.

4.2.3.2 Liquid Effluents

Waste water streams from the Fort Nelson gas plant are segregated into two systems (see Figure 4-3).

4.2.3.21 Stream 1

Boiler feedwater treatment blowdown is directed to one of two lime ponds. Generally, the effluent quality is unsatisfactory with respect to suspended solids and pH. Suspended solids are allowed to settle in this pond and the supernatant is diluted with the effluent from the aeration lagoon before discharge. No specific measures are taken to control the pH of the combined discharge.

Two lime ponds are used alternately. While one is in use, the other is left to dry. Dried sludge is then disposed of in a landfill on-site.

4.3.2.22 Stream 2

Process facilities waste water, domestic sewage, and surface runoff are all directed to a central effluent treatment plant. Process waste water includes streams from steam generation (boiler blowdown) sweetening facilities, sweetening solvent regeneration facilities, dehydration plant, sour water stripper, and floor drain washings. The combined waste waters contain organic contaminants.

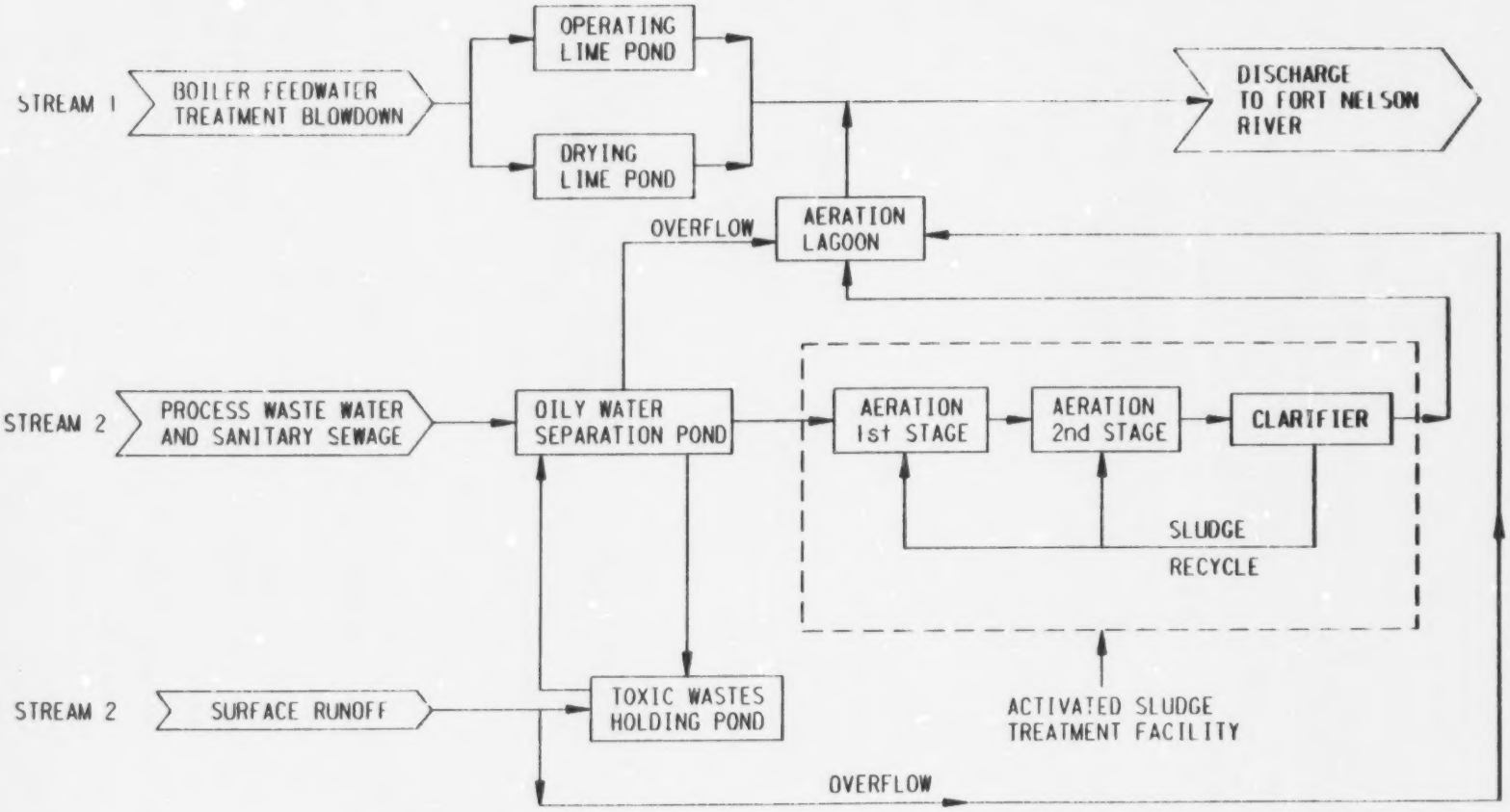


FIGURE 4-3
FORT NELSON GAS PLANT
WASTE HANDLING FLOW DIAGRAM

The central effluent treatment plant consists of an oily water separation pond, an extended aeration/activated sludge facility, an aerated lagoon, and a holding pond. Process waste waters and domestic sewage are directed to the oily water separation pond where oil and grease are removed. The effluent then passes to the activated sludge facility which includes first and second stage aeration tanks and clarifiers. Sludge from the clarifiers is recycled to the aeration tanks and the clarifier supernatant is discharged to the large aerated lagoon where it is further aerated using two surface aerators. The lagoon supernatant is then mixed with the lime pond supernatant, and discharged to the Fort Nelson River via a submerged outfall.

The holding pond is a relatively new addition to the treatment system and acts as a buffer for the activated sludge system influent. The pond is used to manage the inflow to the activated sludge unit by controlling the influent flow rate. Wastewaters from the pond are introduced to the activated sludge system when treatment capacities are sufficient.

A block diagram for the effluent treatment system for the Fort Nelson gas plant is shown in Figure 4-3. Table 4-1 summarizes quantities, treatment, and methods of disposal for liquid effluents generated at the plant. A monthly summary of the performance of the waste water treatment plant in 1983 and the Waste Management Permit requirements for various discharge parameters are presented in Table 4-2. The table shows that in 1983 the plant was unable to regularly meet BOD_5, ammonia and suspended solids discharge requirements as specified in the permit. At the time of the site visit (February, 1984), the plant personnel were considering corrective actions to mitigate the problem. Only those parameters specified in the permit are monitored. No information was available on trace elements, organics, priority pollutants, etc.

TABLE 4-1

Westcoast Transmission - Fort Nelson Gas Plant
Liquid Effluent Summary

Waste Stream	Effluents	Approximate Quantities (m^3/day)	Treatment	Disposal
1	Boiler feedwater treatment blowdown	70	- Holding pond for suspended solids removal	- Pipeline to Fort Nelson River
2	Process waste water including:			
	- boiler blowdown	200	- All wastes processed at central treatment facility consisting of:	- Pipeline to Fort Nelson River
	- sweetening regeneration filter waste	20		
	- sweetening process drains	100	- oil separation pond	
	- dehydration process drain	30	- activated sludge facility	
	- sour water stripper	N.A.	- aerated lagoon	
	- sulphur plant process drain	N.A.	- holding pond	
	Domestic Sewage	20		
	Surface Runoff	N.A.		

N.A. - Not Available.

TABLE 4-2

Westcoast Transmission - Fort Nelson Gas Plant - 1983 Combined (Streams 1 and 2)
Effluent Quality

Parameters	BOD_5	Ammonia	Suspended Solids	Oil and Grease	Phosphate	Sulphide	pH	Temp.	Dissolved Oxygen
Permit[a] Requirement	45 mg/L	15 mg/L	60 mg/L	10 mg/L	10 mg/L	1.0 mg/L	6.5-8.5	Max. 27°C	Min. 1.0 mg/L
Actual Quality[b] by Month									
January	322	55.7	63.0	6.3	0.44	0.03	8.3	4.7	9.3
February	346	60.0	67.9	2.2	0.35	0.15	8.2	4.6	7.8
March	365	54.2	155.6	4.6	0.43	0.50	8.4	5.0	7.1
April	263	46.1	54.0	3.1	0.29	0.08	8.2	11.0	5.1
May	227	56.8	52.5	4.5	0.18	0.18	7.5	14.0	5.1
June	450	168.7	74.4	5.6	0.35	1.06	7.7	17.0	5.0
July	283	271.0	97.0	9.5	2.10	4.30	7.4	18.0	4.3
August	50	165.0	89.2	7.7	0.40	0.48	7.4	18.0	4.0
September	62	7.1	58.5	6.5	0.13	0.03	8.2	23.0	2.9
October	91	49.8	100.0	6.3	0.34	0.04	8.1	9.8	8.5
November	173	167.0	121.0	7.1	0.49	0.04	7.9	6.5	9.0
December	82	42.7	74.0	2.5	0.49	0.04	8.0	5.5	11.4

[a] for weekly composites made up of hourly samples.

[b] averages of four weekly composite samples.

4.3 WESTCOAST TRANSMISSION-PINE RIVER PLANT

4.3.1 PLANT DESCRIPTION

The Pine River Gas Plant, located 24 km southwest of Chetwynd, British Columbia, is owned and operated by Westcoast Transmission Co. Ltd. Construction of the plant commenced in July 1978 and operations began in February 1980. The facility has the capacity to process 7400 x 10^3 cubic metres per day of raw gas from Getty Oil (Canada) Ltd., British Petroleum, and Quasar. The combined raw gas stream has an H_2S concentration of 16 percent, a CO_2 concentration of about 11 percent, and a hydrocarbon make-up that consists almost entirely of methane. The plant produces 5900 x 10^3 cubic metres of sales gas per day, with daily production of sulphur amounting to approximately 1000 tonnes.

The gas plant is self-sufficient with power generated on-site. Heating for the plant building and pipe tracing is provided by a glycol circulation system. Raw water is pumped to the plant site from two wells located at Hasler Flats.

4.3.2 PROCESS DESCRIPTION

The Pine River gas plant utilizes a sulfinol gas sweetening process for removal of hydrogen sulphide and carbon dioxide, a dry desiccant gas dehydration facility, and a sulphur recovery system using a four converter sub-dewpoint Claus process. Figures 4-4 and 4-5 show simplified process flow diagrams for the Pine River facility.

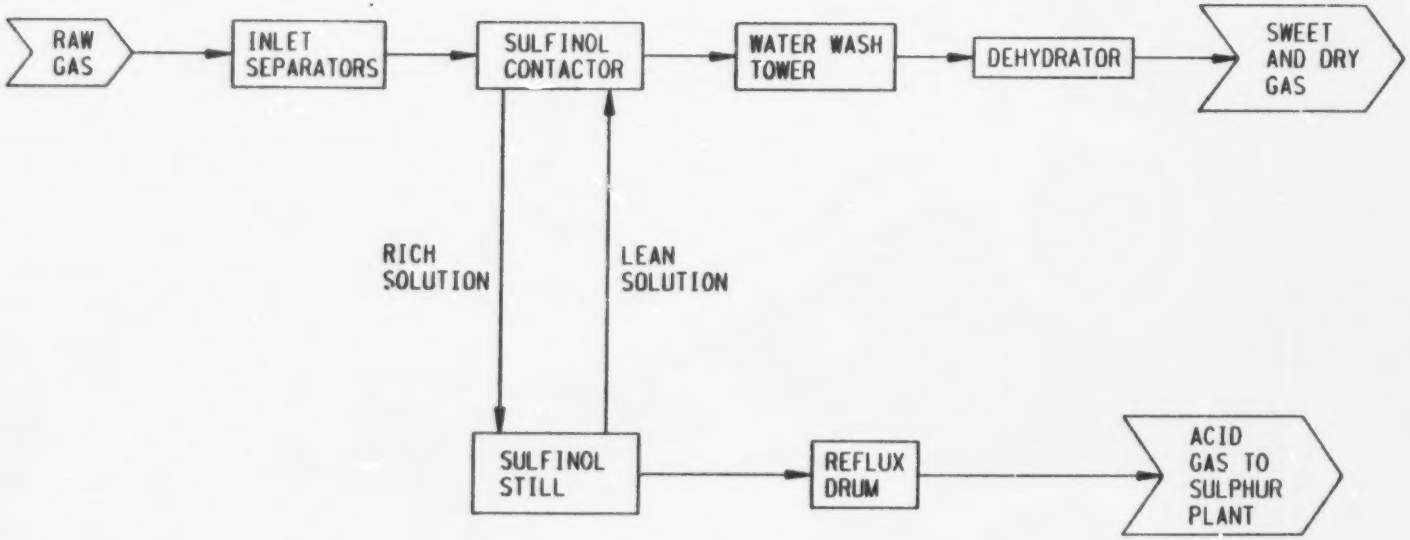


FIGURE 4-4

PINE RIVER GAS PLANT

GAS PROCESSING FLOW DIAGRAM

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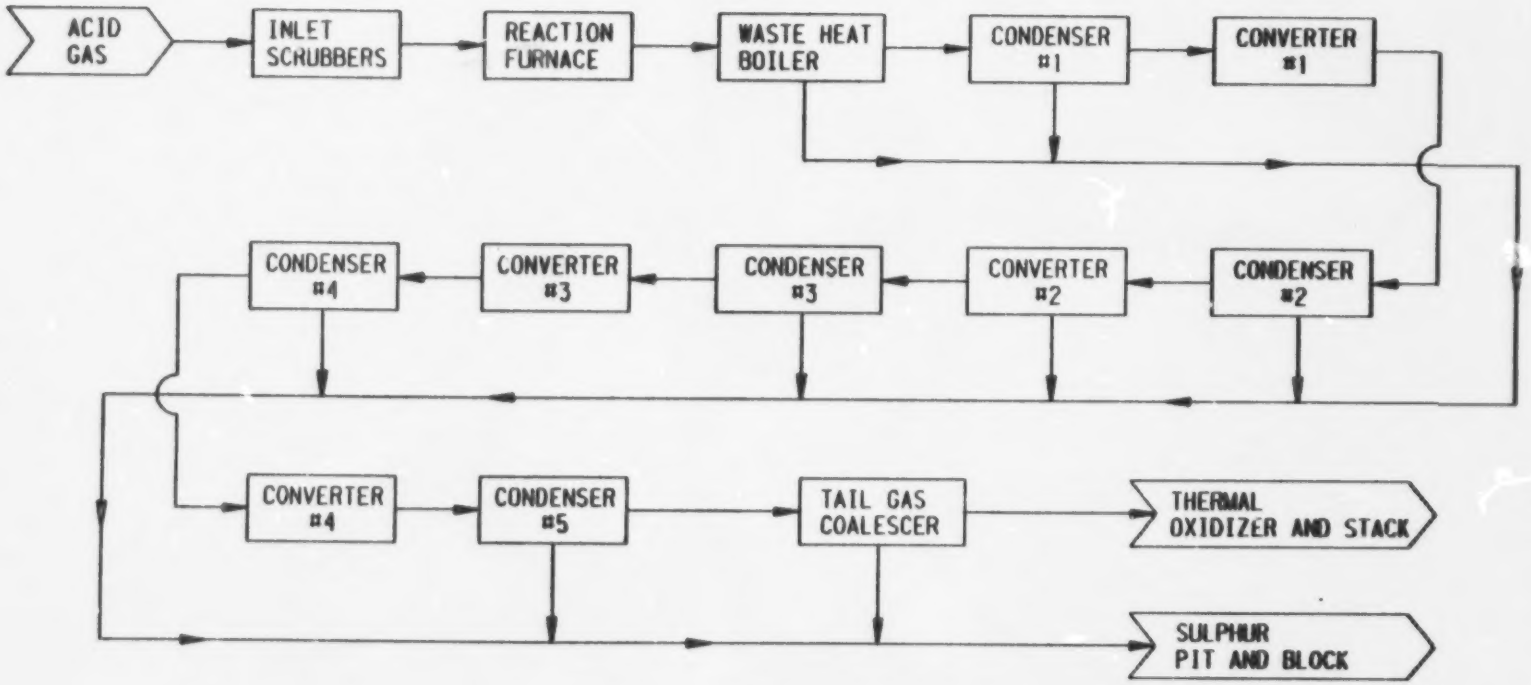

FIGURE 4-5
PINE RIVER GAS PLANT
SULPHUR RECOVERY FLOW DIAGRAM
TRAIN I OF 2

4.3.2.1 Gas Treating Plant

The sweetening of the gas stream is accomplished by counter-current contact with sulfinol in high pressure Sulfinol Contactors. The H_2S and CO_2 that is absorbed in the sulfinol is recovered by heating in the reboilers and regenerator. Sulfinol is then pumped back to the contactor. Acid gases go to the sulphur plant for processing.

4.3.2.2 Dehydration

Sweetened gas is dehydrated in a two tower silica gel dry desiccant system. There are no LPG recovery facilities at the plant.

4.3.2.3 Sulphur Plant

The sulphur plant consists of two trains with a reaction furnace, four converters, and five condensers each. The sulphur recovery efficiency is 99 percent.

4.3.3 WASTE HANDLING PROCESSES

4.3.3.1 Solid Wastes

Solid wastes at the gas plant consist mainly of silica gel desiccants and spent alumina catalysts. The desiccants, amounting to 36,000 kg, are to be disposed of every 4 years in a landfill adjacent to plant property. Spent alumina catalysts, some 900,000 kg in total, are to be disposed of every 7 years in the landfill which is used exclusively for plant wastes. Combustible garbage is transported to the Chetwynd municipal landfill. To date, no desiccants or spent catalysts have been disposed of.

Waste sludge from the plant's waste water treatment unit is disposed of in a three cell sludge drying bed with a total area of 350 square metres. Approximately 70 L per day of wet sludge (1.3 kg of dry solids) is applied to the beds. Sludges also collect in the two evaporation ponds and the emergency holding pond. To date, the ponds have not been desludged.

4.3.3.2 Liquid Effluents

The Pine River plant was originally designed on the basis of zero discharge of waste waters to the receiving environment (with the exception of sulphur block surface runoff). This was to be accomplished by discharging all liquid effluents to a series of evaporation ponds. After about a year of operation it became apparent that effluent volumes were too high and evaporation rates insufficient for containment of all waste water in the existing ponds. As a result, in 1981 a program of spray irrigation was initiated to discharge some of the effluent from two of the waste streams described below. At present, a maximum of about 13000 m^3 of effluent is disposed of by spray irrigation each year. The irrigation site is a 50 m by 500 m forested area just north of the main plant site. The irrigation site is not accessible to the public and is over 2 km away from the nearest residence. Spraying of the effluent, which is monitored for BOD, suspended solids, pH, and oil and grease prior to release, takes place between June and September each year. A soil monitoring program is undertaken each year after spray irrigation is complete.

A summary of the plant's main waste streams is given in Table 4-3 along with a brief description of volumes, treatment and final disposal for each effluent stream. Figure 4-6 presents treatment systems for the four streams. The streams and their respective treatments are discussed below.

TABLE 4-3

Westcoast Transmission - Pine River Gas Plant
Liquid Effluent Summary

Waste Stream	Effluents	Approximate Quantities[b]	Treatment	Disposal
1	Plant sewage Building washdown	- 8600 m^3/year	- Settling - Oil separation - Extended aeration activated sludge digestion	- Retention in evaporation ponds - Pond overflow disposed of by spray irrigation[a]
2	Boiler blowdown Boiler feedwater treatment backwash	- 6700 m^3/year (to boiler blowdown evaporation ponds)	- 90 percent of boiler blowdown is vaporized in the blowdown evaporators - remaining 10 percent plus BFW treatment backwash is released to evaporation ponds	- Retention in evaporation ponds - Pond overflow disposed of by spray irrigation[a]
3	Knockout liquids	- 164 m^3/day (to holding pond - upset conditions only)	- None	- Incineration or secure storage
4	Sulphur block runoff	- 43 m^3/day (max. average flow)	- pH correction	- Released to watershed

a - a maximum of 13000 m^3/year of combined effluent from waste streams 1 and 2 is disposed of by spray irrigation.

b - total generated: approximately 85 - 249 m^3/d

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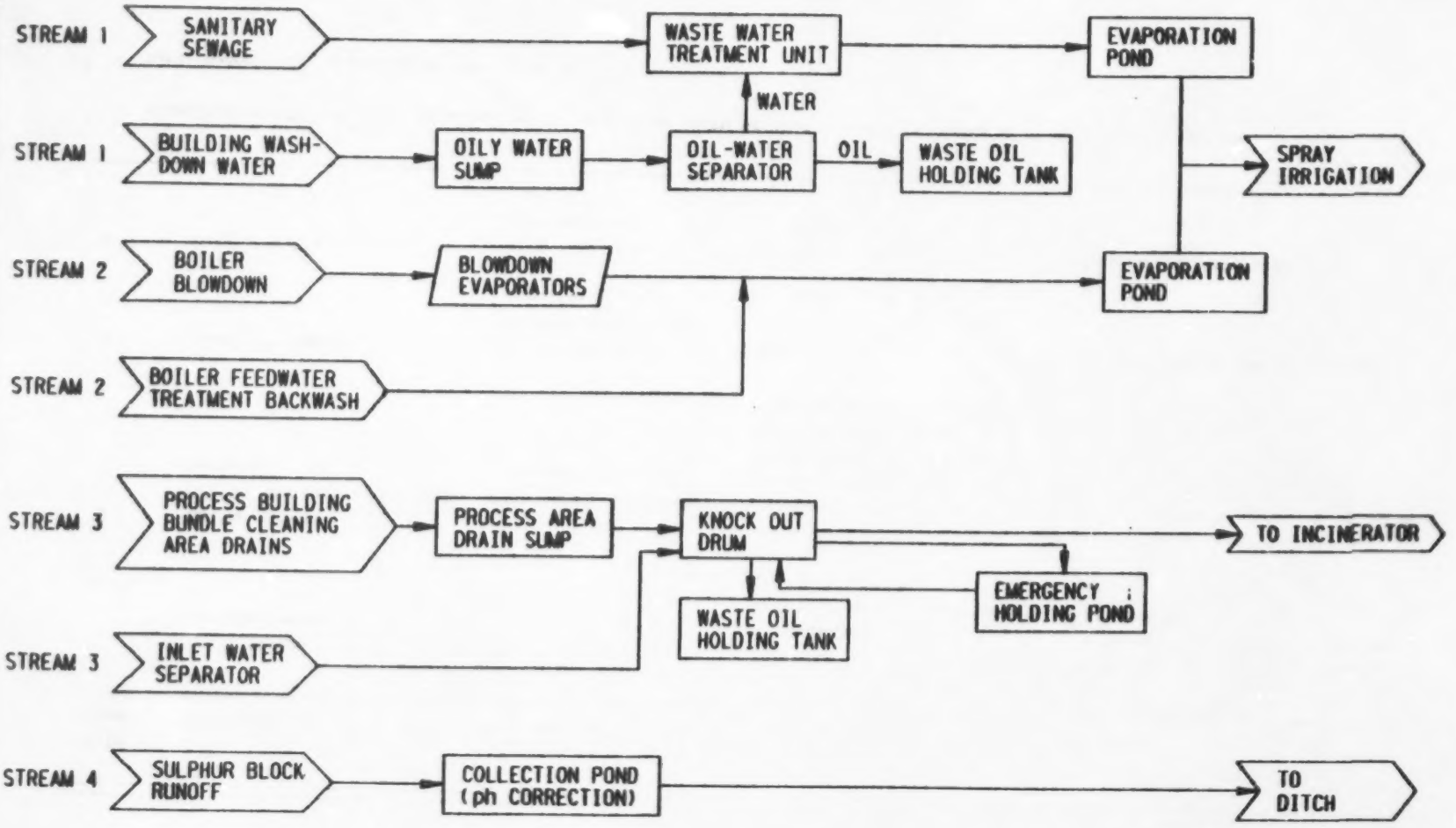

FIGURE 4-6
PINE RIVER GAS PLANT
WASTE HANDLING FLOW DIAGRAM

4.3.3.21 Stream 1

Stream 1 carries effluent from plant washrooms, utility buildings, and shop washdown water. The treatment for the stream consists of settling, oil removal, and aeration and clarification in a waste water treatment unit. Following treatment, the effluent is discharged to three evaporation ponds where, after approximately 8 months detention time, it is mixed with stream 2 and finally disposed of by spray irrigation. The waste oil is sold to an outside contractor for reclamation and disposal.

Tables 4-4 and 4-5 provide analytical results of supernatant from the waste water treatment evaporation ponds and from the blowdown evaporation ponds (stream 2). The metals analysis in Table 4-5 is based on a single sample taken in 1982.

4.3.3.22 Stream 2

The second stream consists of boiler blowdown and boiler feedwater treatment backwash waste water. Under normal operating conditions, 90 percent of the boiler blowdown is evaporated with waste heat in the blowdown evaporators, while the remaining 10 percent is combined with feedwater treatment backwash and discharged to one of two blowdown evaporation ponds. During periods of low plant throughput (approximately 30 percent of the time), the blowdown evaporators are inoperative and most of the boiler blowdown is directed to the waste water treatment evaporation ponds. Effluent in the blowdown evaporation ponds is retained for at least 8 months before being combined with effluent from the waste water treatment evaporation ponds for disposal by spray irrigation. Table 4-6 provides the 1981 average water quality for combined

TABLE 4-4

Westcoast Transmission - Pine River Gas Plant
1982 Evaporation Ponds Water Quality

Parameter[a]	Units	NE[b]	SE[c]	W[d]	N[e]	S[f]
Total Suspended Solids	mg/L	32	40	24	L1	L1
Total Dissolved Solids	mg/L	380	340	430	350	1100
pH	-	9.3	9.1	9.0	8.2	7.7
Electrical Conductivity	Micromhos per cm	600	580	720	720	1400
Alkalinity (as $CaCO_3$)	mg/L	201	212	120	24	23
B.O.D.$_5$	mg/L	18	74	68	L10	L10
C.O.D.	mg/L	160	360	280	43	12
T.O.C.	mg/L	18	47	48	L1	L1
Calcium	mg/L	46	42	36	56	110
Magnesium	mg/L	12	8.4	7.8	11	23
Sodium	mg/L	56	54	77	30	195
Potassium	mg/L	5.78	5.20	4.75	1.01	1.98
Boron	mg/L	0.17	0.16	0.24	0.01	L0.01
Chloride	mg/L	22	22	41	30	127
Sulphate	mg/L	60	95	180	160	580
Phosphate (as P)	mg/L	3.35	3.68	4.12	0.03	0.03
Nitrite(as nitrogen)	mg/L	.002	.003	.004	.002	.003
Nitrate(as nitrogen)	mg/L	.76	1.13	1.17	.13	.06
Ammonia (as N)	mg/L	.07	.07	.07	L0.01	L0.01
Total Kjeldahl Nitrogen (as N)	mg/L	4.6	16.0	17.0	0.43	L0.01
Oil and grease	mg/L	1	1	1	2	1
Total Coliform	/100mL	L4	L4	12	40	6
Fecal Coliform	/100mL	L4	L4	L4	12	L2

a - the Pollution Control Permit contains no specific water quality requirements for effluent discharged to evaporation ponds. The required quality of effluent disposed of by spray irrigation is shown in Table 4-6
b - northeast waste water treatment evaporation pond
c - southeast waste water treatment evaporation pond
d - west waste water treatment evaporation pond
e - north blowdown evaporation pond
f - south blowdown evaporation pond

TABLE 4-5

Westcoast Transmission - Pine River Gas Plant
Evaporation Ponds Supernatant Metals Analysis

Metal		NE[a] (ppm)	SE[b] (ppm)	W[c] (ppm)	N[d] (ppm)	S[e] (ppm)	Detection Limit (ppm)
Aluminum	Al	L[f]	L	L	L	L	0.15
Antimony	Sb	L	L	L	L	L	0.15
Arsenic	As	L	L	L	L	L	0.30
Barium	Ba	0.026	0.028	0.021	0.037	0.024	0.001
Beryllium	Be	L	L	L	L	L	0.003
Bismuth	Bi	L	L	L	L	L	0.5
Boron	B	0.14	0.13	0.17	0.031	L	0.01
Cadmium	Cd	L	L	L	L	L	0.025
Calcium	Ca	44.2	34.9	32.8	59.9	108.	0.01
Chromium	Cr	L	L	L	L	L	0.03
Cobalt	Co	L	L	L	L	L	0.02
Copper	Cu	L	L	L	L	L	0.015
Iron	Fe	L	0.066	0.45	L	L	0.030
Lead	Pb	L	L	L	L	L	0.08
Magnesium	Mg	11.2	7.33	7.10	11.5	21.3	0.001
Manganese	Mn	0.054	0.078	0.14	L	L	0.003
Mercury	Hg	-	-	-	-	-	-
Molybdenum	Mo	L	L	L	L	L	0.04
Nickel	Ni	L	L	L	L	L	0.025
Phosphorus	PO_4	2.91	4.70	6.45	L	L	0.4
Potassium	K	5.78	5.20	4.75	1.01	1.98	0.01
Selenium	Se	-	-	-	-	-	-
Silicon	SiO_2	6.79	5.44	6.06	L	0.47	0.08
Silver	Ag	L	L	L	L	L	0.03
Sodium	Na	64.8	57.8	71.2	37.7	215.	0.1
Strontium	Sr	0.11	0.090	0.080	0.12	0.21	0.001
Tin	Sn	L	L	L	L	L	0.03
Titanium	Ti	L	L	L	L	L	0.006
Tungsten	W	-	-	-	-	-	-
Uranium	U	-	-	-	-	-	-
Vanadium	V	L	L	L	L	L	0.01
Zinc	Zn	L	L	L	L	L	0.015

a - northeast waste water treatment evaporation pond
b - southeast waste water treatment evaporation pond
c - west waste water treatment evaporation pond
d - north blowdown evaporation pond
e - south blowdown evaporation pond
f - L = less than detection limit
g - from single 1982 sample

TABLE 4-6

Westcoast Transmission - Pine River Gas Plant
Average Water Quality for Spray Irrigated Effluent[a]

Parameter	Concentration (mg/L)	Regulatory Requirement (mg/L) Maximum
pH	7	6.5-8.5
Total solids	530	-
Suspended solids	11	60
Dissolved solids	519	-
BOD_5	21	45
COD	80	-
Calcium	58	-
Magnesium	14	-
Sodium	65	-
Total phosphate	1.7	-
Oil and grease	1	10
Fecal coliform	5	-

[a] - from 1981 samples.

spray irrigated effluent and the regulatory requirement for various parameters. The table indicates that the discharge was well within the permit limits.

4.3.3.23 Stream 3

Liquid wastes with high concentrations of hydrocarbons and other organic or inorganic contaminants are disposed of by recycling, secure storage, or incineration. Sour water stripper bottoms are all recycled to process solutions while waste oil from oil/water separators and rotating equipment is collected and sold for reclamation. About 3000 litres per year of sulfinol reclaimer wastes are sealed in drums and removed from the site by a hazardous materials disposal contractor. Effluent from the knock out drum servicing the inlet separators and the fuel gas scrubbers is routed to a knock out liquids holding tank. Under normal operating conditions, this waste is incinerated by an auxiliary burner nozzle in the sulphur plant's tail gas incinerator. However during plant shutdown or under upset conditions, the effluent is directed to a clay lined waste liquids holding pond where it is stored until such time as it can be returned to the plant for incineration.

4.3.3.24 Stream 4

Runoff from the sulphur storage area is collected in an evaporation pond and corrected for pH if required. The existing Waste Management Permit allows the discharge of this effluent to the watershed, however to date this has not been necessary since evaporation rates have exceeded the rate of runoff accumulation. Runoff from the remainder of the plant site is not collected or treated.

4.4 PETRO-CANADA AND WESTCOAST TRANSMISSION - TAYLOR PLANT

4.4.1 PLANT DESCRIPTION

The Taylor plant, located at Taylor, British Columbia, is jointly owned and operated by Petro-Canada and Westcoast Transmission and consists of an oil refinery and a gas processing plant. Various additions and expansions have been undertaken since the original facility was constructed in 1957. A waste water treatment unit was added in 1974 and in 1981, the refinery capacity was expanded and an activated sludge biological treatment unit was added to the waste water treatment plant.

Raw gas feed consists of a sour, wet gas, with a hydrogen sulphide content of 2 percent and a relatively high concentration of heavier hydrocarbons (C_3+). The heavy hydrocarbons are concentrated in an LPG recovery system and further processed in the plant's fractionation facilities.

The petroleum refinery processes two varieties of crude, B.C. light crude (approximate 80% of feed) and Boundary Lake crude (approximately 20% of feed). At present, the plant processes about 2700 m^3/d of crude oil, 11,100 x 10^3 m^3/d of sales gas, and 1000 m^3/d of condensate and LPG's.

The plant produces most of its own electrical power with B.C. Hydro supplying the remainder. Water is obtained from the Peace River, by way of a pumphouse located one-half mile south of the plant site. More than 99% of the water pumped to the plant (some 150 million litres per day) is used for once through cooling, and is returned to the river at a temperature of approximately 27°C.

4.4.2 PROCESS DESCRIPTION

The sour, wet gas is collected from a number of reservoirs and passed to the head of the gas processing portion of the Taylor facility.

Condensed liquid hydrocarbons entering the system with the natural gas are removed in the inlet separators, prior to processing of the sour gases. Gas sweetening is achieved by MEA absorption. The acid gases are then removed from the amine solution and routed to Westcoast Transmission's sulphur recovery facility located adjacent to the Taylor Plant. Removal of sulphur is accomplished using the modified Claus process. The sulphur plant is a two train system with a sulphur recovery efficiency of 95%. Sulphur production is approximately 400 tonnes per day.

The sweetened gas leaves the amine contactors and enters the absorbers where absorption oil removes the liquefied petroleum gases and natural gasoline. Natural gas is then dehydrated to absorb any water which may be present. The recovered propane, butane and natural gasolines are removed from the absorption oil and routed to the liquefied petroleum gas recovery system located in the gasoline plant for further processing.

Process flow diagrams for gas and LPG processing are shown in Figures 4-7 and 4-8.

4.4.3 WASTE HANDLING PROCESSES

The collection and treatment of the gas processing wastes at the Taylor plant are closely integrated with the collection and treatment of the refinery wastes. In fact, the plant uses common sewers and treatment systems to collect and treat wastes. It is therefore not possible to segregate and discuss the two wastes separately. Hence the

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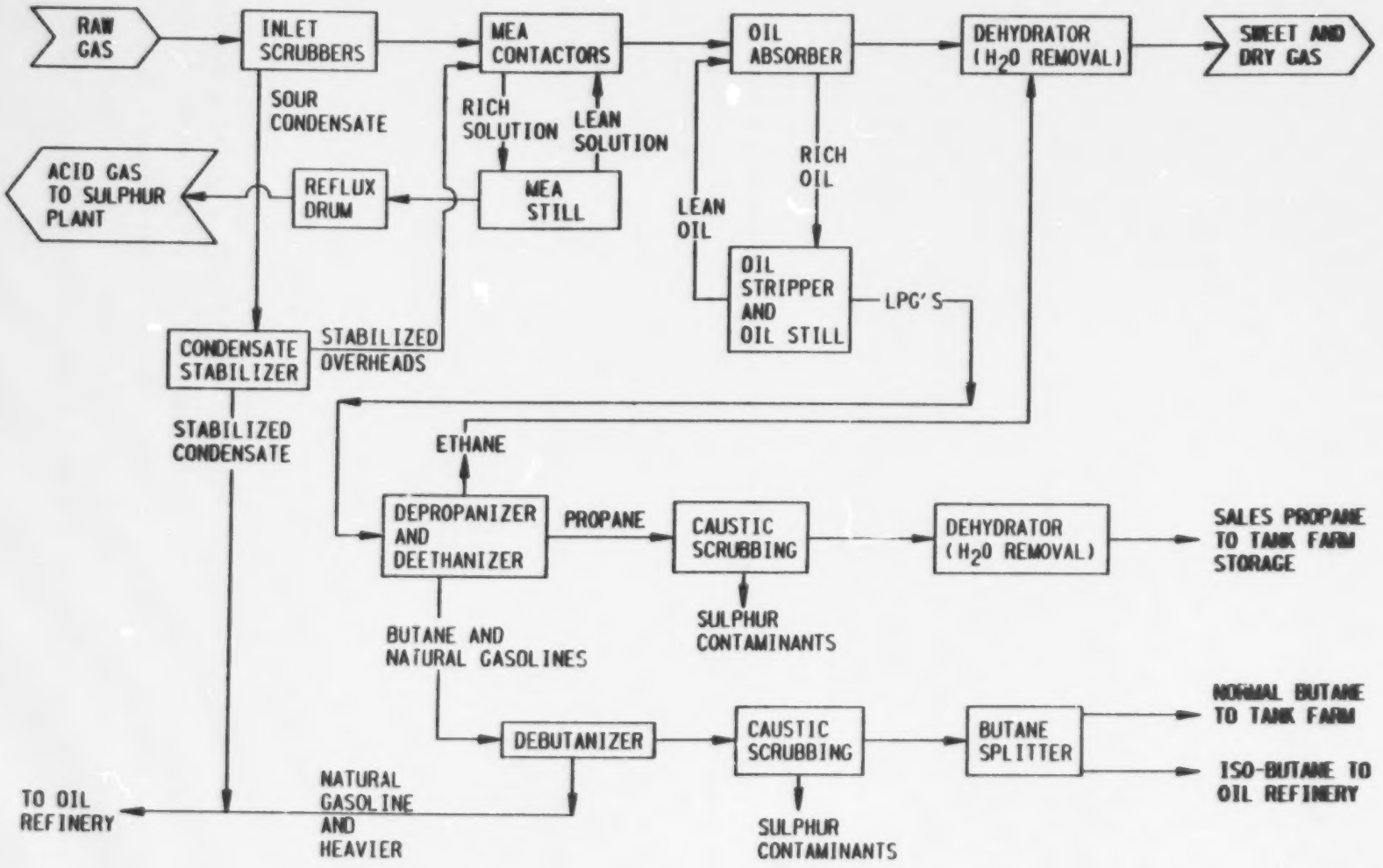

FIGURE 4-7
TAYLOR PLANT
GAS AND LPG PROCESSING FLOW DIAGRAM

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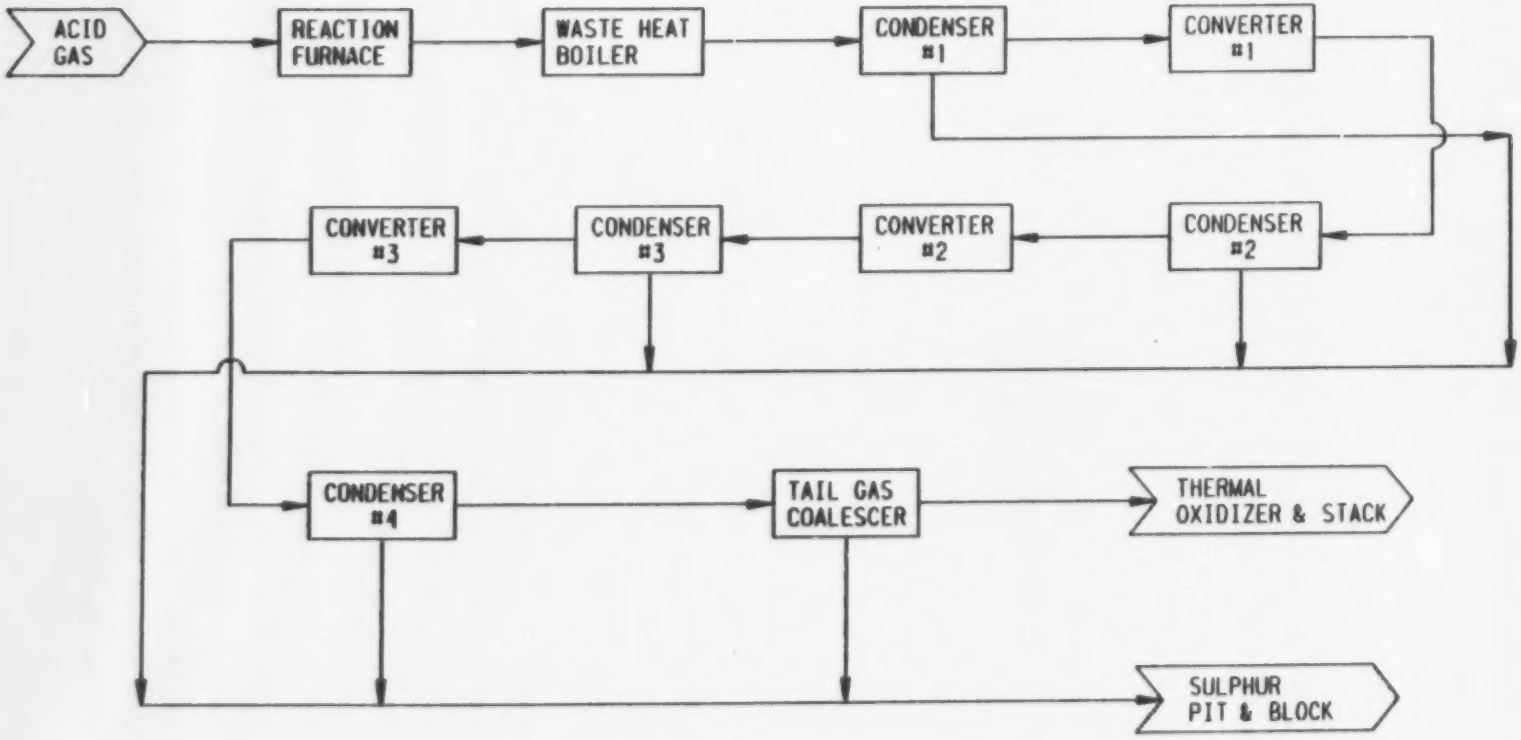

FIGURE 4-8
TAYLOR PLANT
SULPHUR RECOVERY FLOW DIAGRAM
(1 OF 2 TRAINS)

analytical results presented in the tables contain contributions from the refinery wastes.

4.4.3.1 Solid Wastes

Solid wastes at the Taylor plant are disposed of by landfilling or landfarming.

4.4.3.11 Landfill

Two landfills are located on-site, each situated in gravelly soil approximately 50 m above the groundwater table. The first landfill is used exclusively for the disposal of spent dehydration desiccants and activated alumina catalysts. Wastes are covered with soil shortly after disposal to eliminate dusting. The second landfill is used for the disposal of all other solid wastes with the exception of sludges. This includes approximately 16 m^3/week of domestic refuse, asphalt and cat-cracked catalysts, and general refuse. Cover material is applied to the waste weekly.

4.4.3.12 Landfarming (sludge disposal)

Prior to 1974, sludges were disposed of in two landfills separate from those described above. Since 1974, sludges from the two API separators and all plant holding ponds and lagoons have been landfarmed at a 4.5 hectare site immediately north of the main plant site area. Oily sludges from the API separators are collected once or twice per year and applied to a 1.6 hectare portion of the landfarm site. Sludges from holding ponds and lagoons are distributed on the remaining 2.9 hectares once or twice per year (depending on the rate of sludge accumulation). A combined total of approximately 1000 m^3 of sludge is landfarmed annually.

Each spring the landfarm site is prepared for the May-to-October operating season by plowing and discing. Nitrogen, phosphorus, and potassium fertilizers are added to the soil to satisfy nutritional requirements. Sludge is then spread on the prepared bed, dried, and cultivated into the soil.

Surface runoff from the landfarm area is intercepted and directed to the main plant runoff collection/treatment system.

4.4.3.2 Liquid Effluents

Liquid effluents are segregated into five waste streams. Table 4-7 summarizes the sources, volume, treatment and disposal for each waste stream. The waste water flow diagram and treatment system are shown in Figure 4-9. The five streams are discussed below.

4.4.3.21 Stream 1

Oily and/or sour process waste waters from the entire closed drain system, the crude refinery open drain, and the gas plant and refinery flare liquid knockout drums are treated in a system consisting of two API separators, a sour water stripper, an equalization pond, an activated sludge biological treatment unit, an aeration pond, and a final settling pond. Waste waters are initially routed through the first API separator which removes oil and also functions as a primary sedimentation basin. Effluent is then directed to the sour water stripper for the removal of sulphides, and some phenols ammonia. Two-thirds of the sour water stripper bottoms are directed to the second API separator while remaining one-third is recycled to the refining process. Residual oil is removed in the second API separator and the effluent directed to the equalization basin after pH correction. Oil collected in the API separators is recycled to the refinery while the separator sludge is removed

TABLE 4-7

Petro-Canada and Westcoast Transmission - Taylor Plant
Liquid Effluent Summary

Waste Stream	Effluents	Approximate Quantities	Treatment	Disposal
1	Oily and Sour Plant Process Effluents - all closed drains - Knock out drum effluents - Crude refinery open drains	Total for Streams 1 & 2 = 1000-1500m^3/d	- Oil separation - Sour water stripping - Activated sludge digestion - Clarification - Aeration - Settling	Discharge to Peace River
2	Non-Oily and Non-Sour Plant Process Effluents - Gas processing and hydrocarbon recovery open drains - Desalter - Sulphur plant open drain - Spend caustic tank - Crude refinery open drains from: - unifines - condensate fractionator - platformer		- Oil separation - Activated sludge digestion - Clarification - Aeration - Settling	Discharge to Peace River
3	Powerhouse Floor Drains Boiler Blowdown		- Settling - Aeration	Discharge to Peace River

...Cont'd

TABLE 4-7 (Cont'd)

Waste Stream	Effluents	Approximate Quantities	Treatment	Disposal
4	Surface Runoff - Tank Farm - Refinery, gas plant - Powerhouse	250 m^3/d (yearly ave.)	- As per stream one or, if quality is acceptable - oil seperation - settling	Discharge to Peace River
5	Sanitary Sewage	N.A.	- Taylor municipal waste treatment facility	
6	Cooling Water	150 000 m^3/d	- Oil separation for 40% subject to hydrocarbon contamination - Remaining 60% untreated	Discharge to Peace River

N.A. - Not Available

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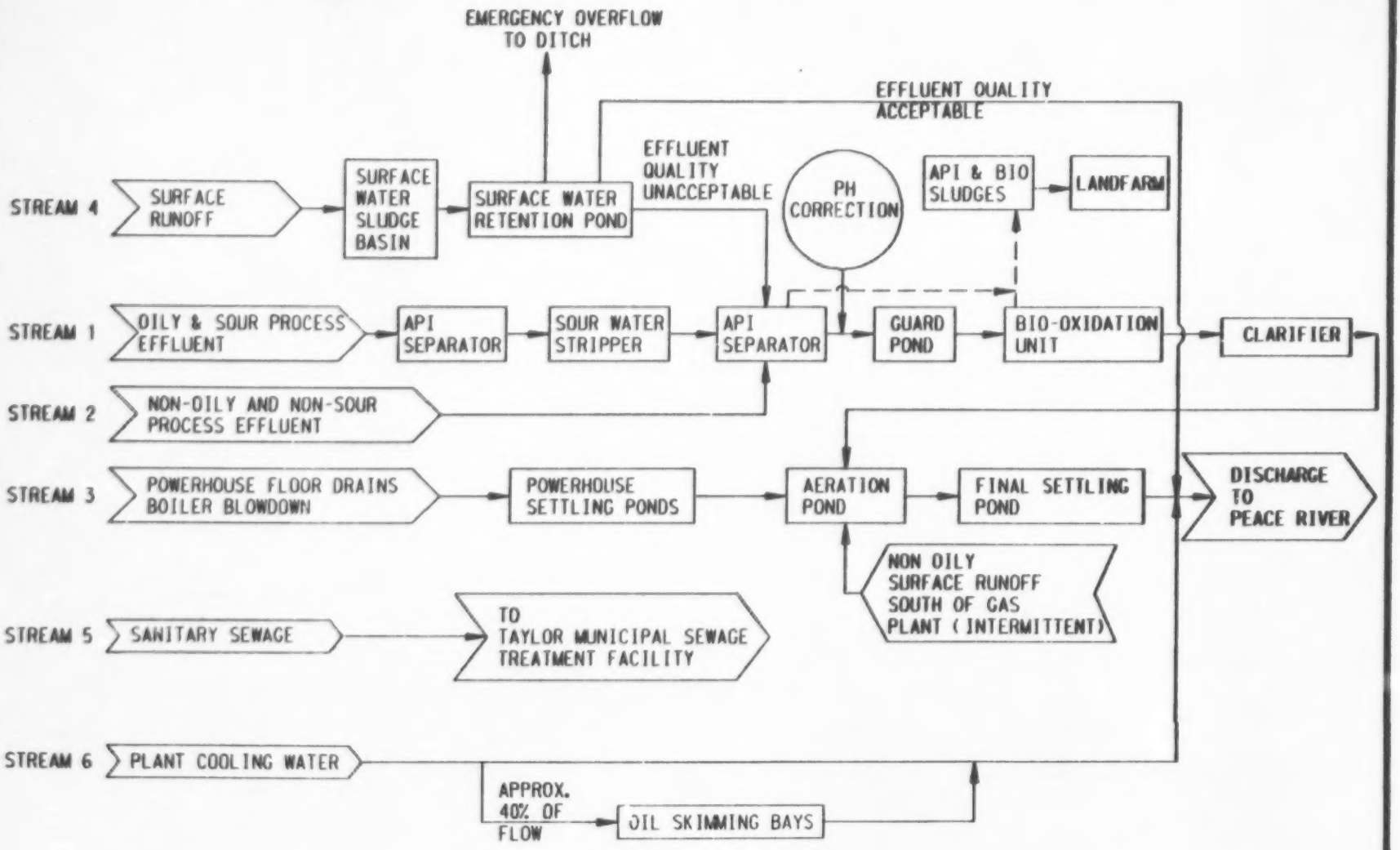

FIGURE 4-9

TAYLOR PLANT
WASTE HANDLING FLOW DIAGRAM

by vacuum truck and transported to the landfarm. The equalization basin acts as a buffer to minimize shock loads to the biological treatment unit. Following treatment in the Biox unit, treated effluent is discharged to an aeration pond with a 10 day retention time. Overflow from the pond is discharged to the final settling pond for further polishing before being released to the Peace River.

4.4.3.22 Stream 2

Process wastes (non-sour) which are relatively non-oily are directed to the above waste treatment system downstream of the sour water stripper. Effluents from the gas processing and hydrocarbon recovery open drains, the desalter, the sulphur plant, the spent caustic tank, and portions of the crude refinery open drain system (i.e. from unifiner, condensate fractionator, and platformer) make up this waste stream.

4.4.3.23 Stream 3

This waste water stream consists of effluent from powerhouse floor drains and boiler blowdown. Wastewaters are directed to one of the two parallel powerhouse settling ponds for removal of suspended solids and are then discharged to the Peace River via the aeration ponds and final settling pond. Ocassionally, the aeration pond also receives non-oily surface runoff from the area south of the gas plant.

4.4.3.24 Stream 4

This waste water stream consists of surface runoff from the tank farm, refinery gas plant, and powerhouse. It is routed through a surface water sludge basin for oil removal before being passed to the surface water retention pond. At this point

the waste water is monitored for hydrocarbons, pH, total suspended solids, and phenols and, if found unacceptable, it is directed to the second API separator. If the surface water pond effluent quality is acceptable, it is discharged directly to the Peace River without further treatment.

4.4.3.25 Stream 5

This waste water stream consists of sanitary sewage from the plant. It is discharged directly to the Taylor municipal sewage treatment facility.

4.4.3.26 Stream 6

The cooling water system is a once-through process in which approximately 40 percent of the flow is subject to hydrocarbon contamination resulting from equipment failures (pump glands, exchanger seals, bundle breaks, etc.). Consequently this portion of the flow is directed through a series of oil skimming bays before being combined with the remainder of the cooling water. The combined water is returned to the Peace River at a temperature between 16°C and 28°C.

The waste water treatment system performance summaries for process effluent, surface runoff, and discharged cooling water are shown in Tables 4-8, 4-9 and 4-10 together with the corresponding licensing requirements. The sampling methods are specified by the Waste Management Permit. Grab samples only are required, either weekly or monthly. The results in Table 4-8 are for weekly samples, except for total solids and orthophosphate, which are analyzed once a month. The results of Tables 4-9 and 4-10 represent monthly grab samples.

TABLE 4-8

Petro-Canada and Westcoast Transmission - Taylor Plant - 1983 Discharged Process Effluent Quality

Parameter / Permit Requirement		T. LIQUID CHG.[a] $M^3/d-(M^3/M)$	Discharge[b] 2050 M^3/d	pH 6.5 - 8.5	COD[d] mg/L	BOD_5 22.8 g/M^{3c}	Phenol 0.17 g/M^{3c}	Sulphide 1.0 mg/L	Ammonia 5.3 g/M^{3c}
JANUARY	Avg.	2829.5	1313.6	7.3	229	26.7	0.127	L 1.2	26.8
(Total)	Range	(87713.5)	(40772.0)	7.2 - 7.4	136 - 343	11.1 - 50.1	.004 - .250	L 1.0 - 1.8	22.3 - 34.7
FEBRUARY	Avg.	2617.3	1054.4	7.5	166	5.8	0.061	L 1.0	11.2
(Total)	Range	(73248.8)	(29522.6)	7.3 - 7.8	150 - 200	4.4 - 7.3	.025 - .125	L 1.0	8.1 - 14.1
MARCH	Ave.	2675.0	928.2	7.4	144	4.9	0.094	L 1.0	8.7
(Total)	Range	(82923.6)	(28774.0)	7.2 - 7.5	121 - 160	2.4 - 10.1	.031 - .174	L 1.0 - 1.0	5.2 - 14.2
APRIL	Avg.	2611.4	1468.4	7.6	150	21.8	1.424	L 1.0	20.1
(Total)	Range	(78,342.1)	(44,050.7)	7.5 - 7.8	120 - 169	8.4 - 55.7	.006 - 3.762		16.1 - 24.6
May[e]	Avg.	332.3	1158.5	7.8	115	55.8	5.75	L 0.5	33.9
(Total)	Range	(10,300.3)	(35,915.0)	7.3 - 8.3	63 - 159	24.4 - 97.6	.003 - 28.6		3.5 - 71.8
JUNE	Avg.	2285.5	1307.0	7.4	172	6.5	0.037	L 0.5	1.4
(Total)	Range	(68564.7)	(39210.6)	6.5 - 8.7	145 - 222	5.2 - 8.0	.001 - .143		0.6 - 2.8
JULY	Avg.	3071.0	1375.0	6.9	134	14.0	0.001	L 0.5	5.2
(Total)	Range	(95201.2)	(42629.5)	6.6 - 7.1	112 - 173	6.3 - 29.5	.001 - .002		2.0 - 9.3
AUGUST	Avg.	3152.5	1234.0	7.5	185	32.9	0.003	L 0.5	13.4
(Total)	Range	(97728.1)	(38264.0)	7.1 - 7.9	143 - 250	18.8 - 70.8	.001 - .004		5.6 - 24.7
SEPTEMBER	Avg.	2941.0	1026.6	7.5	143	11.5	0.001	L 0.5	5.0
(Total)	Range	(88230.8)	(30798.0)	7.3 - 7.5	131 - 157	8.7 - 14.7	.001 - .002		2.4 - 7.4
OCTOBER	Avg.	2870.2	1332.8	7.8	168	14.2	0.002	L 0.5	7.1
(Total)	Range	(88975.0)	(41318.2)	7.4 - 8.2	131 - 185	5.6 - 20.4	.001 - .003		1.1 - 23.6
NOVEMBER	Avg.	2738.4	1536.0	7.7	167	32.9	0.003	L 0.5	13.0
(Total)	Range	(82,151.8)	(46,079.0)	7.4 - 8.0	142 - 209	20.4 - 47.7	.002 - .006		7.5 - 18.3

DECEMBER - Results not available

a - Total Liquid charge includes Crude, LPG and pipeline liquids throughput
b - Process effluent discharge volume
c - Grams/metre^3 of refinery throughput including crude, LPG, and pipeline liquids
d - No permit limit
e - The plant was shut down for most of May

.../Cont'd

TABLE 4-8 (Cont'd)

Parameter		Fluoride	Cyanide	Oil & Grease	Phosphate	Suspended Solids	Total Solids	96-h TLm[b] Vol%
Permit Requirement		10.0 mg/L	0.1 mg/L	8.0 g/m^3[a]	1.0 mg/L	60 mg/L	1500 mg/L	
JANUARY	Avg.	4.2	0.059	2.3	1.35	58.2	1246.0	77.5
	Range	2.7 - 7.6	.013 - .100	1.1 - 4.6	0.8 - 1.6	26.8 - 72.4	-	55.0 - 100.0
FEBRUARY	Avg.	5.2	0.012	1.7	1.12	33.9	1670.0	100.0
	Range	4.8 - 5.4	.009 - .013	1.0 - 2.5	0.4 - 1.7	28.0 - 37.6	-	-
MARCH	Ave.	4.1	0.008	1.1	1.0	45.5	1540.0	100.0
	Range	1.8 - 7.4	.002 - .017	0.9 - 1.4	-	24.8 - 88.4	-	-
APRIL	Avg.	1.5	L 0.003	2.8	0.4	34.8	853.0	100.0
	Range	0.8 - 3.3	L .002 - 0.006	0.7 - 6.7	-	20.8 - 46.4	-	-
MAY[c]	Avg.	7.7	0.004	6.3	0.9	42.6	1116.0	100.0
	Range	5.0 - 9.2	0.003 - 0.005	2.8 - 10.5	-	34.0 - 50.4	-	-
JUNE	Avg.	6.0	0.005	0.8	0.6	49.3	944.4	100.0
	Range	5.2 - 7.0	0.002 - 0.008	0.3 - 1.3	0.3 - 1.2	34.8 - 60.0	-	-
JULY	Avg.	3.3	0.006	0.4	0.24	44.2	1196.0	100.0
	Range	2.8 - 3.6	0.002 - 0.009	0.2 - 0.5	-	20.0 - 58.6	-	-
AUGUST	Avg.	3.1	L 0.003	0.6	1.25	43.5	1144.0	100.0
	Range	2.0 - 4.6	L 0.002 - .005	0.2 - 0.7	-	32.0 - 67.6	-	-
SEPTEMBER	Avg.	2.4	L 0.003	0.7	1.3	28.0	960.0	79.0
	Range	1.9 - 2.8	L 0.001 - 0.010	0.3 - 1.4	0.2 - 2.4	21.2 - 39.6	-	-
OCTOBER	Avg.	2.9	.016	1.2	0.85	32.8	1055.0	79.0
	Range	1.8 - 3.9	.013 - .021	0.7 - 1.7	-	23.6 - 38.0	-	58.7 - 100.0
NOVEMBER	Avg.	5.6	.022	0.8	1.0	36.8	972.4	100.0
	Range	3.4 - 8.1	.012 - .034	0.4 - 1.5	-	19.6 - 60.4	-	-

DECEMBER - results not available

[a] - Grams/metre^3 of refinery throughput including crude, LPG, and pipeline liquids
[b] - No permit limit
[c] - The plant was shut down for most of May

TABLE 4-9

Petro-Canada and Westcoast Transmission - Taylor Plant
1982 Storm Runoff Quality

Parameter Permit Requirement	Water Flow (L/month)	Oils and Grease 2.9 g/m^{3a}	Suspended Solids 60 mg/L	Phenols 0.17 g/m^{3a}
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	12.7×10^6	-	-	-
May	11.8×10^6	-	-	-
June	6.36×10^6	0.52	-	0.01
July	12.3×10^6	0.09	26	0.01
August	22.7×10^6	0.95	73	0.01
September	13.2×10^6	0.12	17	0.02
October	9.5×10^6	0.06	-	0.01
November	0	0	0	0
December	0	0	0	0

[a] - Grams/metre^3 of refinery throughput including crude, LPG, and pipeline liquids.

TABLE 4-10

Petro-Canada and Westcoast Transmission Taylor Plant
1981 Discharged Cooling Water Quality

Parameter	Discharge	pH	Oil and Grease	Temperature
Permit Requirement	(L/month)	(6.5-8.5)	(2.0 mg/L above background)	(32°C Max.)
January	1.46×10^8	WRL[a]	L[b] 1.0	-
February	1.55×10^8	WRL	L 1.0	-
March	1.46×10^8	WRL	1.3	-
April	1.43×10^8	WRL	L 1.0	-
May	1.48×10^8	WRL	L 1.0	-
June	1.51×10^8	WRL	L 1.0 - 3.5	-
July	1.38×10^8	WRL	L 1.0 - 2.3	-
August	1.20×10^8	WRL	L 1.0 - 2.1	30 - 33
September	-	-	-	-
October	-	-	-	-
November	-	-	-	-
December	-	-	-	-

[a] - within required limits
[b] - less than

4.5 OCELOT CHEMICALS - KITIMAT PLANT

4.5.1 PLANT DESCRIPTION

Ocelot Chemicals' methanol production facility, located approximately 3 km south of Kitimat, British Columbia, uses 370 million cubic metres of natural gas feedstock to produce 400,000 tonnes of methanol annually. Natural gas feedstock, which is delivered to the methanol plant by a Pacific Northern Gas pipeline, has an H_2S content less than 16 ppm (i.e. as per typical pipeline gas specifications - see Table A-3). Raw water for the boiler feedwater and the circulating water cooling system is taken from the Kitimat River. The plant has been in operation since 1982.

4.5.2 PROCESS DESCRIPTION

The Ocelot plant produces methanol by reforming the molecular structure of a hydrocarbon, in this case natural gas (i.e. methane). As a first step in the process residual H_2S and the mercaptans (added as gas odorant) are removed. The presence of even a small amount of these compounds in the feedstock is enough to poison the catalysts used in the methanol conversion process. A combination of zinc oxide and nickel-molybdenum oxide is used to reduce the H_2S and mercaptan concentrations to negligible levels. No elemental sulphur is formed in this process.

The purified natural gas is then combined with steam and passed through a furnace which converts the gas to carbon dioxide, carbon monoxide and hydrogen. The gases are then cooled, compressed, and circulated through a converter to produce crude methanol. Refined methanol is distilled from the crude and directed to storage tanks.

The process flow diagram for the methanol production facility is shown in Figure 4-10.

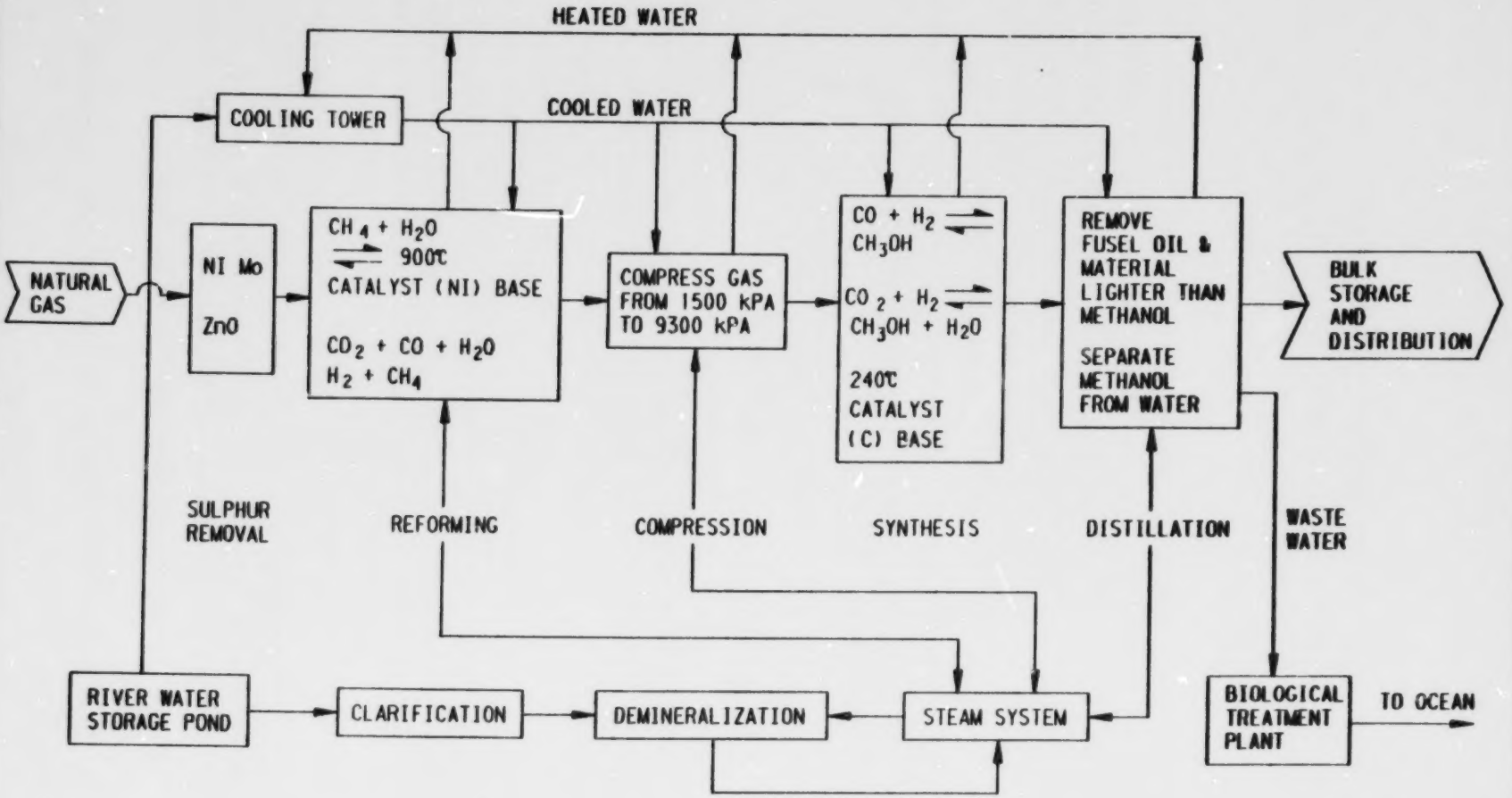

FIGURE 4-10

OCELOT CHEMICALS KITIMAT PLANT

METHANOL PRODUCTION FLOW DIAGRAM

4.5.3 WASTE HANDLING PROCESSES

4.5.3.1 Solid Wastes

There are at present no solid waste disposal facilities at the Ocelot plant. It is anticipated that all spent catalysts, including zinc oxide used in the desulphurization process will be sold for metal reclamation. To date the process is still using the original catalyst batch. Due to the low sulphur content of the feedstock, the life expectancy of the catalyst is expected to be 8 to 10 years. The remainder of solid wastes generated by the plant are disposed of in the Kitimat municipal landfill. This includes general garbage as well as sludges from the septic tank unit and the water treatment effluent settling basin.

4.5.3.2 Liquid Effluents

The four main waste water streams identified at the Ocelot plant are summarized in Figure 4-11 and are described below:

4.5.3.21 Stream 1

Process effluents and plant sewage are directed to a septic tank, a rotating biological contactor treatment unit, and a clarifier. Before being treated the process effluent is neutralized. From the clarifier the treated water is directed to an effluent sump and is then pumped to the Kitimat Arm.

4.5.3.22 Stream 2

Stream 2 consists of boiler blowdown and filter and demineralizer wash water. The demineralizer blowdown is neutralized before combining with the filter wash water and boiler blowdown and flowing to a settling basin for solids

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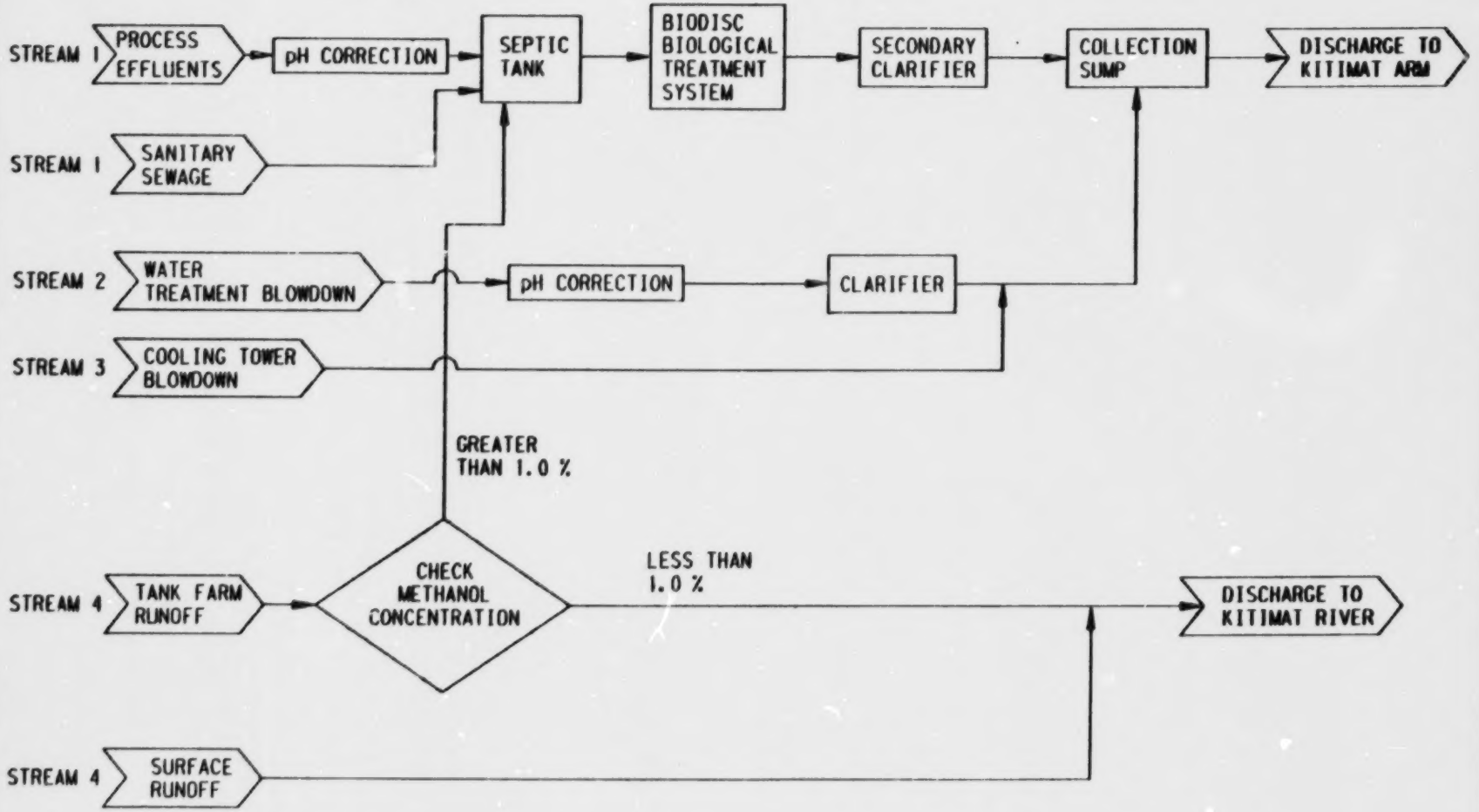

FIGURE 4-11
OCELOT CHEMICALS KITIMAT PLANT
WASTE HANDLING FLOW DIAGRAM

removal. The settling basin overflow is directed to the effluent sump and is then pumped to the Kitimat Arm.

4.5.3.23 Stream 3

Stream 3 is made up solely of cooling water blowdown and is directed to the effluent sump before being discharged to the Kitimat Arm.

4.5.3.24 Stream 4

Stream 4 consists of tank farm drain water and surface runoff. If the tank farm drain water is contaminated, it can be directed to the RBC unit for treatment. Uncontaminated drain water and all surface runoff is discharged directly to the Kitimat River.

Tables 4-11 and 4-12 summarize liquid effluent quantities, treatment, and disposal, as well as the discharge effluent water quality. For comparison purposes, permit requirements for corresponding parameters are also given.

TABLE 4-11

Ocelot Chemicals Kitimat Plant
Liquid Effluent Summary

Waste Stream	Effluents	Approximate Quantities (m^3/day)	Treatment	Disposal
1	Sanitary Sewage Process effluents including: - refining column bottoms - floor drains	- Total for Waste Stream 1 = 560	- Single treatment stream consisting of: - pH correction - septic tank - biodisc - secondary clarification	- Pipeline to ocean outfall on Kitimat Arm
2	Water treatment blowdown including: - filtered water - boiler blowdown - acid and caustic from ion exchange process - chemical drain sump	- Total for Waste Stream 2=1610	1. For water treatment blowdown - neutralization - clarification - dilution in collection sump 2. For cooling tower blowdown - dilution with central treatment system effluent	- Pipeline to ocean outfall on Kitimat Arm
3	Cooling tower blowdown	- Total for Waste Stream 3=150	- Dilution in collection sump	- Pipeline to ocean outfall on Kitimat Arm
4	Tank farm runoff	N.A.[a]	1. Methanol contaminated runoff - directed to biological treatment system	- Pipeline to ocean outfall on Kitimat Arm
			2. Uncontaminated runoff - untreated	- Pipeline to ocean outfall on Kitimat Arm
	Surface runoff	N.A.	- Untreated	- Pipeline to outfall on Kitimat River

[a] Not available

TABLE 4-12

Ocelot Chemicals Kitimat Plant
Required and Observed Waste Water Quality

Effluent Parameters	B.C. Pollution Control Permit Limit[a]	Observed Concentration[b]
Total Suspended Solids	30 mg/L	52 mg/L - Ave. Daily Maximum
COD	30 mg/L	150 mg/L - Ave. Daily Maximum
Cyanide	0.05 mg/L	Less Than 0.05 mg/L
Temperature	22°C Maximum	40°C - Ave. Daily Maximum
pH Range	6.5-8.5	5.3-7.8 Ave. Monthly Minimum
		8.5-9.6 Ave. Monthly Maximum
Toxicity (96 Hr. TLm)	50%	Acceptable except under start-up and normalization mode

[a] - currently under review
- these requirements are for process effluents and sanitary sewage only. The original Pollution Control Permit places no specific restrictions on surface runoff quality except that runoff discharged directly to the Kitimat River must have a methanol concentration less than one percent.
- permit limit is for a monthly composite sample prepared from daily composites of hourly samples.

[b] - combined effluent from waste streams 1 and 2 (1983)

PART 5

IDENTIFICATION OF DATA GAPS

PART 5 - IDENTIFICATION OF DATA GAPS

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5.1 INTRODUCTION

Tables 5-1 through 5-8 tabulate solid waste and liquid effluent data gaps for the four plants surveyed in the study. The data gaps are based on the information obtained from the literature review. In tabulating the data gaps an attempt has been made to identify only those gaps relevant to the gas processing or gas desulphurization facilities. This was especially difficult in the case of the Taylor plant which produces products other than sales gas and where wastes from the refining operation are closely integrated with the wastes from gas processing.

TABLE 5-1

Westcoast Transmission Fort Nelson Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Boiler Water Blowdown	None	
Cooling Tower Blowdown	1. Volumes 2. Disposal practices	
Boiler Water Treatment Blowdown	None	
Inlet Separator Water	1. Volumes 2. Disposal practices	Require confirmation that produced water is routed through main process waste water stream.
Reclaim Drain Sludge	1. Volumes 2. Number of drains	
Regenerator Reflux Drain Effluent	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	
Flash Gas Knock Out Water	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	

.../cont'd

TABLE 5-1 (Cont'd)

Westcoast Transmission Fort Nelson Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Plant Floor Washings	1. Combined effluent constituents	Present information indicates all process drains are combined into one waste stream. Need more information on the process areas contributing to this waste stream.
Process Filter Washings	1. Effluent constituents 2. Volume breakdown - percentage of total filter washing volume contributed by: I) MEA filters II) DEA filters III) K_2CO_3 filters	Present information is for combined filter washings waste stream.
Dehydration Process Water	None	
Sulphur Pelletizing Plant Waste Water	1. Volumes	Sulphur pelletizing plant operated as a separate facility by Petrosol. Information may not be available from Westcoast Transmission.
Drainage from Sulphur Storage Areas	1. Volumes 2. Runoff collection and treatment 3. Pellitizing process waste water - volumes - characteristics	

.../cont'd

TABLE 5-1 (Cont'd)

Westcoast Transmission Fort Nelson Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Sanitary Sewage	None	
Surface Runoff	1. Volumes	
Waste Acids	1. Volumes 2. Effluent constituents 3. Disposal practices	Extent of acid use unknown
Caustic Washes	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	
Used Lubricating Oils	1. Volumes 2. Disposal practices	
Sour Water Stripper Bottoms	1. Volumes	

TABLE 5-2

Westcoast Transmission Fort Nelson Plant - Solid Waste Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Holding and Evaporation Pond Sludges	1. Volumes and constituents of: - lime pond sludges - toxic wastes holding pond sludge - oily water separation pond sludge - aeration lagoon sludge	
Waste Activated Sludge	1. Volumes 2. Disposal practices	
Process Filters	1. Numbers of waste; - K_2CO_3 filters - MEA filters - DEA filters - produced water filters - chemical filters - lube oil filters - diatomaceous earth filters - activated carbon filters - feedwater and potable water filters	Presently have no information on types and numbers of filters used or disposal practices
Spent Lime Slurry from Boiler Feedwater Treatment	1. Volumes 2. Disposal practices	

.../cont'd

TABLE 5-2 (Cont'd)

Westcoast Transmission Fort Nelson Plant - Solid Waste Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Dehydration Process Dry Desiccants	1. Volumes 2. Disposal practices	Silica gel desicants
Spent Catalysts from Sulphur Conversion Process	1. Volumes 2. Disposal practices - determine if catalyst regenerated prior to disposal	Activated alumina catalyst
Spent Catalysts from Tail Gas Clean Up Process	1. Types 2. Volumes	Plant uses Sulfreen tail gas clean up process
Waste Sulphur	1. Volumes and disposal practices for: - waste sulphur - sulphur contaminated with soil - soil contaminated with sulphur	
Chemical Barrels	1. Volumes 2. Disposal practices	
Scrap Metal and/or Equipment	1. Types 2. Possible contaminants 3. Volumes 4. Disposal practices	Landfill used as storage area

TABLE 5-3

Westcoast Transmission Pine River Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Boiler Water Blowdown	1. Volumes	
Cooling Tower Blowdown	1. Type of cooling system - once through - circulating 2. Volumes 3. Disposal practices	
Boiler Water Treatment Blowdown	1. Volumes	
Inlet Separator Water	1. Volumes	General note: Have incomplete information on the number and type of process wastes contributing to the waste water treatment plant and incinerator.
Reclaimer Drain Sludge	None	
Regenerator Reflux Drain Effluent	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	

.../cont'd

TABLE 5-3 (Cont'd)

Westcoast Transmission Pine River Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Flash Gas Knock Out Water	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	
Plant Floor Washings	1. Volumes 2. Effluent constituents	Need to determine which processes are contributing which wastes to the floor drain waste stream.
Process Filter Washings	1. Volumes 2. Effluent constituents 3. Disposal practices - Incineration or treatment	
Dehydration Process Water	1. Volumes 2. Disposal practices	
Knock Out Drum Liquids Holding Tank	1. Volumes 2. Effluent constituents	
Sulphur Plant Waste Water	1. Volumes 2. Disposal practices	
Drainage from Sulphur Storage Areas	None	
Sanitary Sewage	None	

.../cont'd

TABLE 5-3 (Cont'd)

Westcoast Transmission Pine River Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Surface Runoff	1. Volumes	
Waste Acids	1. Volumes 2. Effluent constituents 3. Disposal practices	Extent of acid use unknown
Oil Sludge from Separation Device	1. Volumes	
Caustic Washes	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	
Used Lubricating Oils	1. Volumes	
Sour Water Stripper Bottoms	None	

TABLE 5-4

Westcoast Transmission Pine River Plant - Solid Waste Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Holding and Evaporation Pond Sludges	1. Volumes and constituents of: - blowdown evaporation ponds(2) - treated waste water evaporation ponds(3) - waste liquids holding pond - sulphur storage area containment pond	
Process Filters	1. Numbers of waste; - sulphinol filters - produced water filters - chemical filters - lube oil filters - diatomaceous earth filters - activated carbon filters - feedwater and potable water filters	Presently have no information on types and numbers of filters used or disposal practices.
Spent Lime Slurry from Boiler Feedwater Treatment	1. Volumes 2. Disposal practices	
Dehydration Process Dry Desiccants	1. Location of landfill 2. Description of landfill	Silica gel desiccants

.../cont'd

TABLE 5-4 (Cont'd)

Westcoast Transmission Pine River Plant - Solid Waste Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Spent Catalysts from Sulphur Conversion Process	1. Location of landfill 2. Description of landfill 3. Disposal practices - determine if catalyst is regenerated prior to disposal	Activated alumina catalyst
Waste Sulphur	1. Volumes and disposal practices for: - waste sulphur - sulphur contaminated with soil - soil contaminated with sulphur	
Chemical Barrels	1. Volumes 2. Disposal practices	
Incinerator Ash	1. Volumes 2. Disposal practices	
Scrap Metal and/or Equipment	1. Types 2. Possible contaminants 3. Volumes 4. Disposal practices	

TABLE 5-5

Petro-Canada and Westcoast Transmission Taylor Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Boiler Water Blowdown	1. Volumes	
Cooling Tower Blowdown	None	Once through cooling water
Boiler Water Treatment Blowdown	1. Volumes 2. Disposal practices	
Inlet Separator Water	1. Volumes 2. Disposal practices	Require confirmation that produced water is routed through main water treatment system
Reclaimer Drain Sludge	1. Volumes 2. Number of drains 3. Disposal practices	
Regenerator Reflux Drain Effluent	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	
Flash Gas Knock Out Water	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	

.../cont'd

TABLE 5-5 (Cont'd)

Petro-Canada and Westcoast Transmission Taylor Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Plant Floor Washings	1. Volumes 2. Effluent constituents - gas processing facilities only	Need to determine which processes are contributing to floor drain effluent
Process Filter Washings	1. Volumes 2. Effluent constituents - gas processing facilities only	
Dehydration Process Water	1. Volumes 2. Disposal practices	Require confirmation that waste water is routed through the main treatment system
Sulphur Plant Waste Water	1. Volumes	
Drainage from Sulphur Storage Areas	1. Volumes 2. Disposal practices	Presently have no information on sulphur storage and handling
Sanitary Sewage	None	
Surface Runoff	None	

.../cont'd

TABLE 5-5 (Cont'd)

Petro-Canada and Westcoast Transmission Taylor Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Waste Acids	1. Volumes 2. Effluent constituents 3. Disposal practices	Extent of acid use unknown
Caustic Washes	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	
Used Lubricating Oils	1. Volumes 2. Disposal practices	
Sour Water Stripper Bottoms	1. Volumes	

TABLE 5-6

Petro-Canada and Westcoast Transmission Taylor Plant - Solid Waste Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Holding and Evaporation Pond Sludges	1. Volumes and constituents of: - surface water pond - final settling pond - aeration pond - guard pond - powerhouse settling ponds 2. Disposal Practices - determine if pH at the landfarming site is monitored and maintained at a level sufficient to keep the metals as precipitates	
Oil Sludge from API Separators	1. Volumes - estimate of amount contributed by gas processing facilities only 2. Disposal practices - details of landfarming operation	
Process Filters	1. Numbers of waste: - MEA filters - produced water filters - chemical filters - lube oil filters - diatomaceous earth filters - activated carbon filters - feedwater and potable water filters	Presently have no information on types and numbers of filters used or disposal practices Require estimate of how many waste filters are generated by the gas processing facilities

.../cont'd

TABLE 5-6 (Cont'd)

Petro-Canada and Westcoast Transmission Taylor Plant - Solid Waste Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Dehydration Process Dry Desiccants	1. Types 2. Volumes 3. Description of disposal landfill	
Spent Catalysts from Sulphur Conversion Process	1. Volumes 2. Description of disposal Landfill 3. Disposal practices - determine if catalyst is regenerated prior to disposal	Activated alumina catalyst
Waste Sulphur	1. Volumes and disposal practices for: - waste sulphur - sulphur contaminated with soil - soil contaminated with sulphur	
LPG Storage Tank Bottoms	1. Volumes 2. Disposal practices	
Chemical Barrels	1. Volumes 2. Disposal practices	
Scrap Metal and/or Equipment	1. Types 2. Possible contaminants 3. Volumes 4. Disposal practices	

TABLE 5-7

Ocelot Chemicals Kitimat Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Boiler Water Blowdown	1. Volumes	
Cooling Tower Blowdown	1. Volumes	
Boiler Water Treatment Blowdown	1. Volumes	
Plant Floor Washings	1. Volumes 2. Effluent constituents	Need to determine effluent constituents for floor drains in the desulphurization process area
Process Filter Washings	1. Number and type of filters in desulphurization process 2. Effluent constituents	
Sanitary Sewage	1. Volumes	
Surface Runoff	1. Volumes	
Waste Acids	1. Determine extent of use in desulphurization process 2. Volumes 3. Effluent constituents 4. Disposal practices	

.../cont'd

TABLE 5-7 (Cont'd)

Ocelot Chemicals Kitimat Plant - Liquid Effluent Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Caustic Washes	1. Determine if waste stream exists 2. Volumes 3. Disposal practices	
Used Lubricating Oils	1. Volumes - those used in desulphurization process 2. Disposal practices	

TABLE 5-8

Ocelot Chemicals Kitimat Plant - Solid Waste Data Gaps

Waste Description and/or Source	Outstanding Information	Remark
Holding and Evaporation Pond Sludges	1. Volumes and constituents of: - surface runoff collection tank sludge - septic tank sludge - secondary clarifier unit sludge	
Process Filters	1. Number of filters used in desulphurization process 2. Disposal practices	
Spent Catalysts from Desulphurization Process	1. Volumes	Zinc oxide catalyst
Chemical Barrels	1. Volumes 2. Disposal practices	
Scrap Metal and/or Equipment	1. Types 2. Possible contaminants 3. Volumes 4. Disposal Practices	

PART 6

SAMPLING AND ANALYTICAL PROGRAM

PART 6 - SAMPLING AND ANALYTICAL PROGRAM

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6.1 INTRODUCTION

After completion of the review of available information on the type and character of wastewaters and solid wastes from natural gas processing plants, a limited sampling and analytical program was carried out. Plants to be sampled were selected by Environment Canada. The program concentrated on wastes from the Fort Nelson and Pine River gas plants, facilities which produce sales gas exclusively. Sampling at the Taylor facility (combined refinery and gas processing facility) and the Kitimat plant (methanol plant) was conducted to a lesser degree.

The sampling and analytical program was aimed at providing an indication of the types of contaminants in selected aqueous waste streams and solid wastes. Being limited in scope (i.e. single grab samples were collected), the program was not intended to provide detailed characterization of wastes or treatment efficiencies.

The following sections identify the operating conditions at the plants during sampling, sampling locations and methodologies.

6.2 SAMPLING PROGRAM

In selecting sampling locations at the gas plants, priority was given to wastewater streams suspected of trace organic and inorganic contaminants. Sampling sites were chosen as close as possible to the source. Other samples were collected at points where effluent from several unit processes were combined into a single waste stream. Sludges and other solid waste were selected for sampling and analysis on the basis of typical disposal concerns.

Sample locations are shown on Figures 6-1 to 6-7 for the Fort Nelson, Pine River, Taylor and Kitimat gas plants. A description of each aqueous or solid waste sample collected at the four facilities is provided in Tables 6-1 to 6-4.

The operating conditions at the time of sampling are important considerations in characterizing wastes, particularly aqueous waste streams. Operating conditions at the four natural gas processing plants are summarized as follows:

Fort Nelson

- gas plant was operating normally prior to sampling, but a short-term shutdown was experienced due to compressor failure at the time of sampling (May 17, 1984).

Pine River

- gas plant operations were being phased down in anticipation of seasonal shutdown (May 15, 1984).

Taylor

- gas plant was shutdown for normal maintenance prior to sampling (May 16, 1984).

Kitimat

- plant was operating normally when samples were collected (February, 1984).

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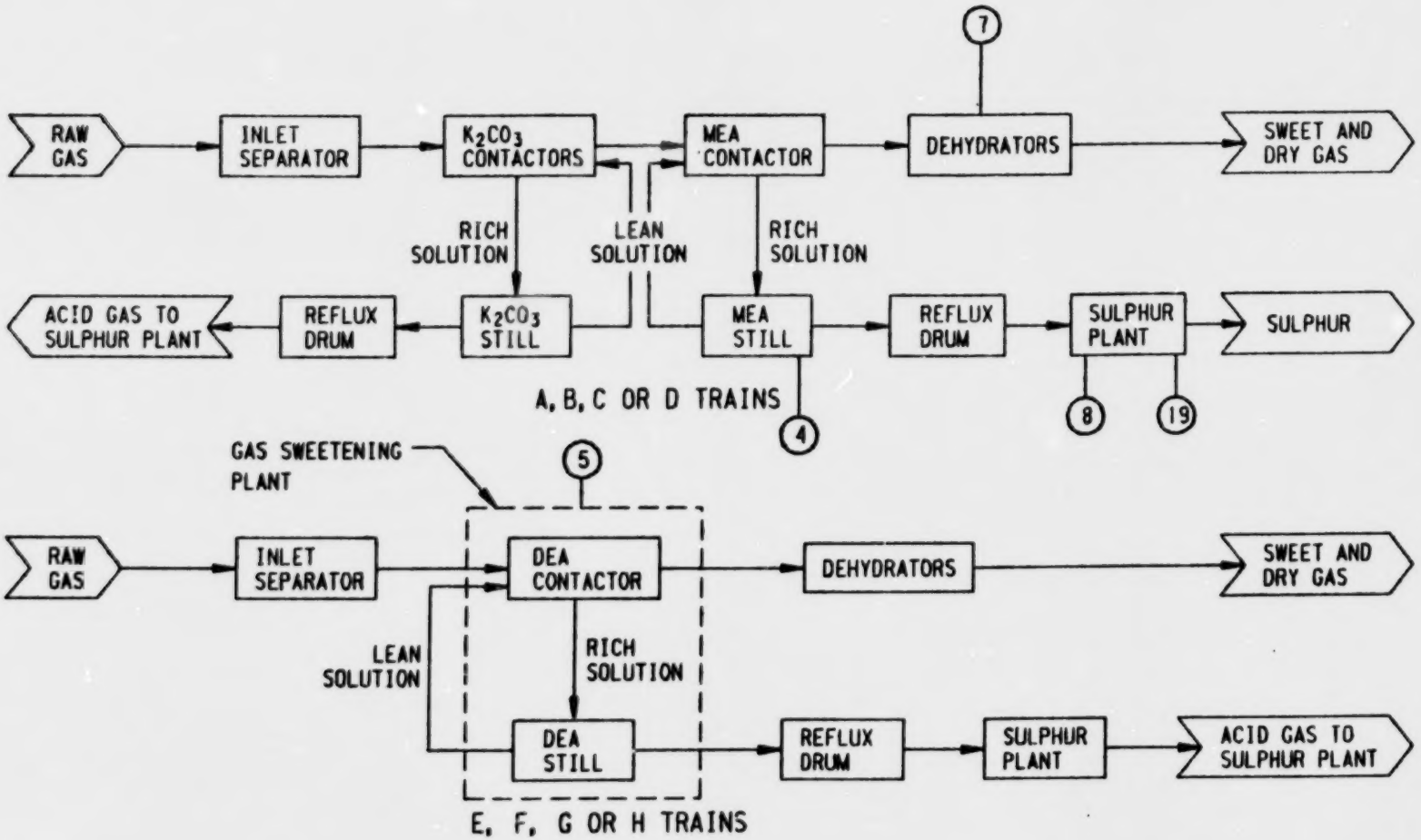

FIGURE 6-1
FORT NELSON GAS PLANT
SAMPLING LOCATIONS

H00514.CHT REV. 0

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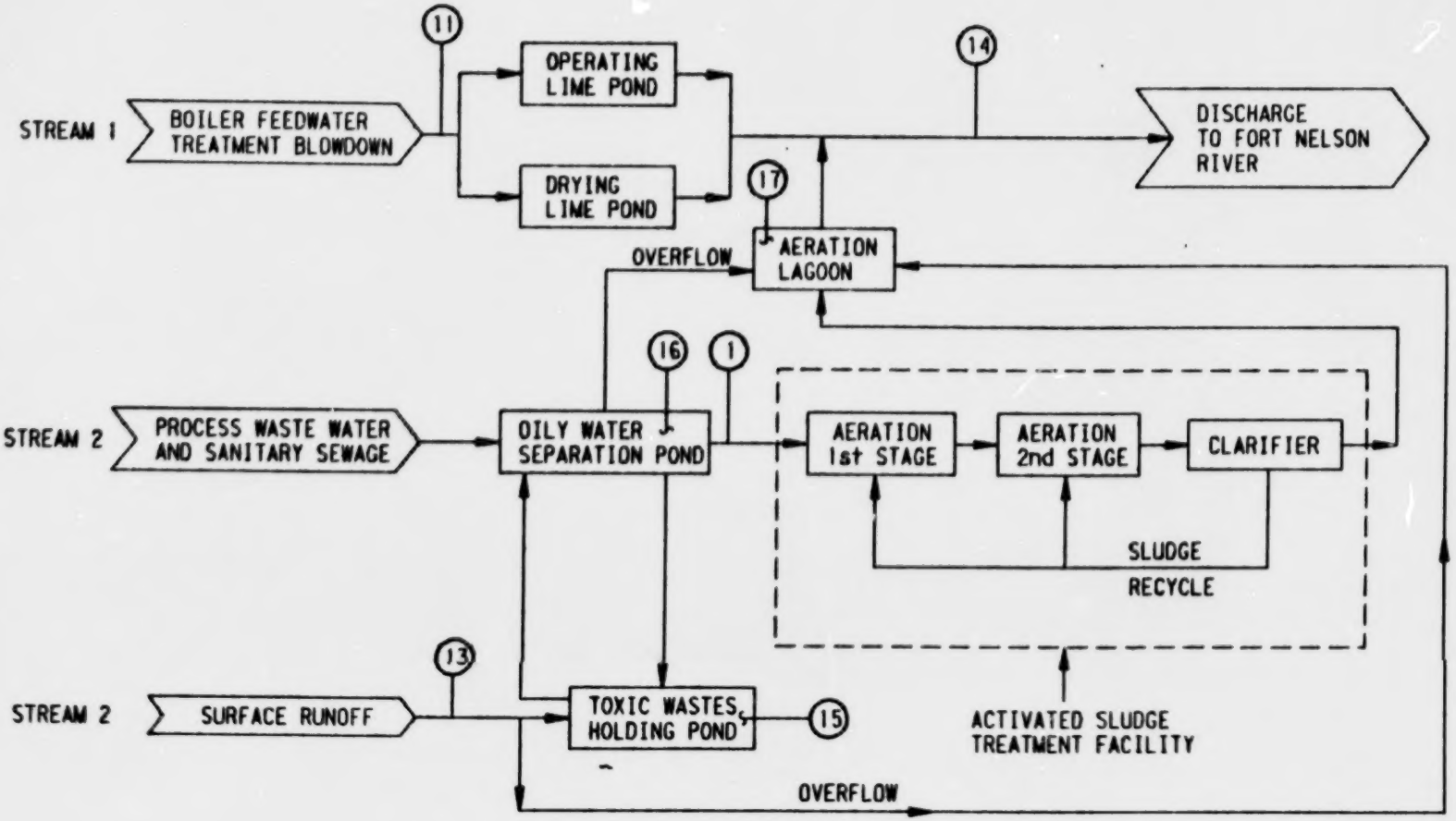

FIGURE 6-2
FORT NELSON GAS PLANT
SAMPLING LOCATIONS

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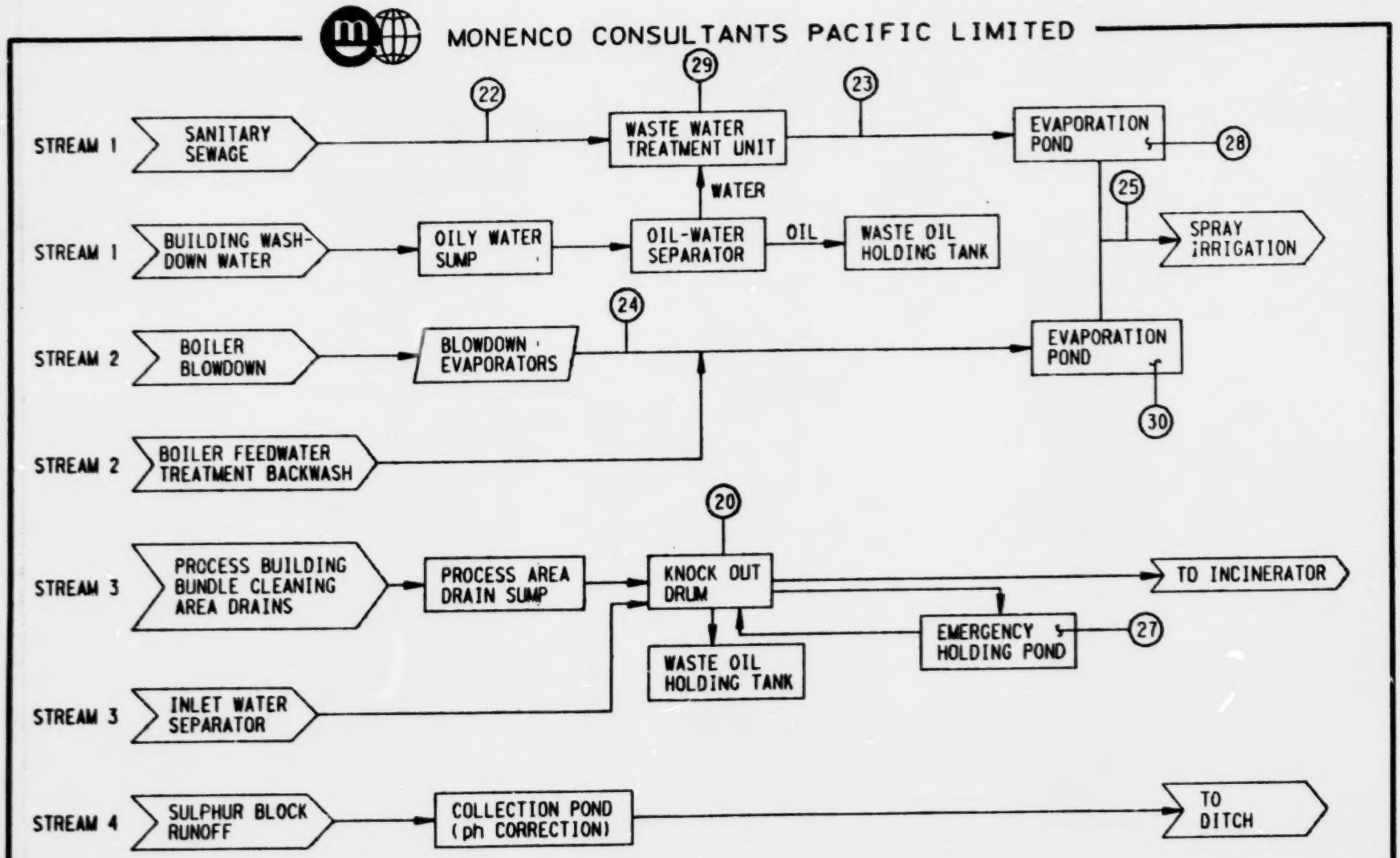

FIGURE 6-3
PINE RIVER GAS PLANT
SAMPLING LOCATIONS

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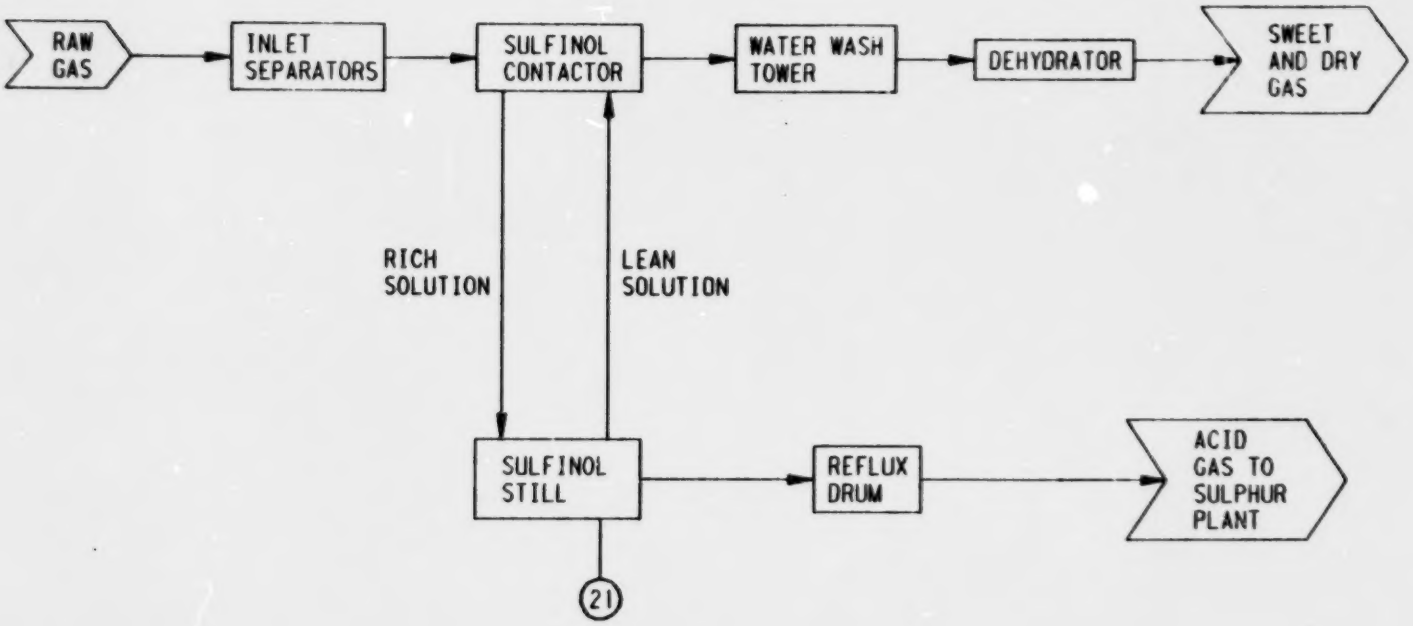

FIGURE 6-4

PINE RIVER GAS PLANT
SAMPLING LOCATIONS

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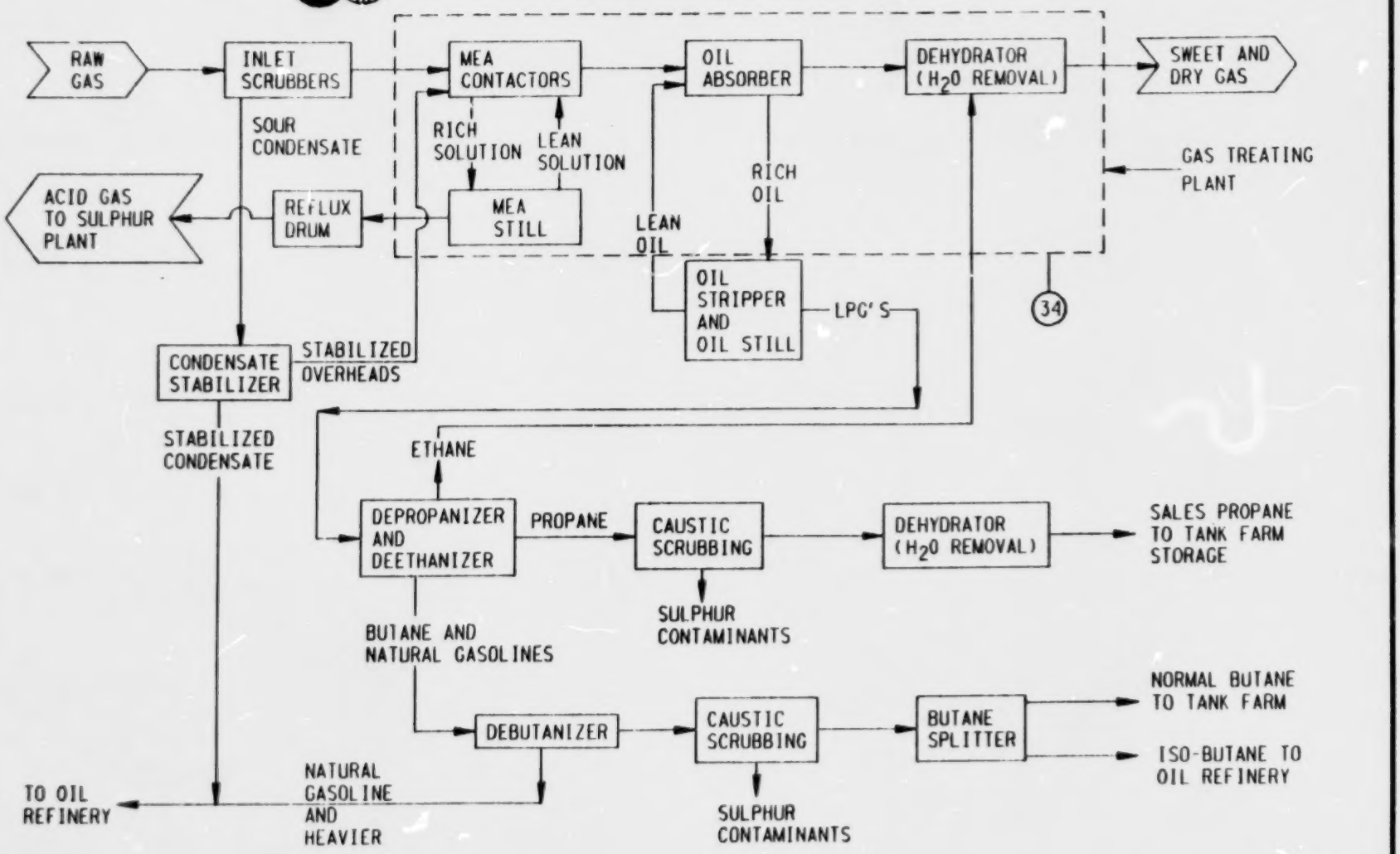

FIGURE 6-5
TAYLOR PLANT
SAMPLING LOCATIONS

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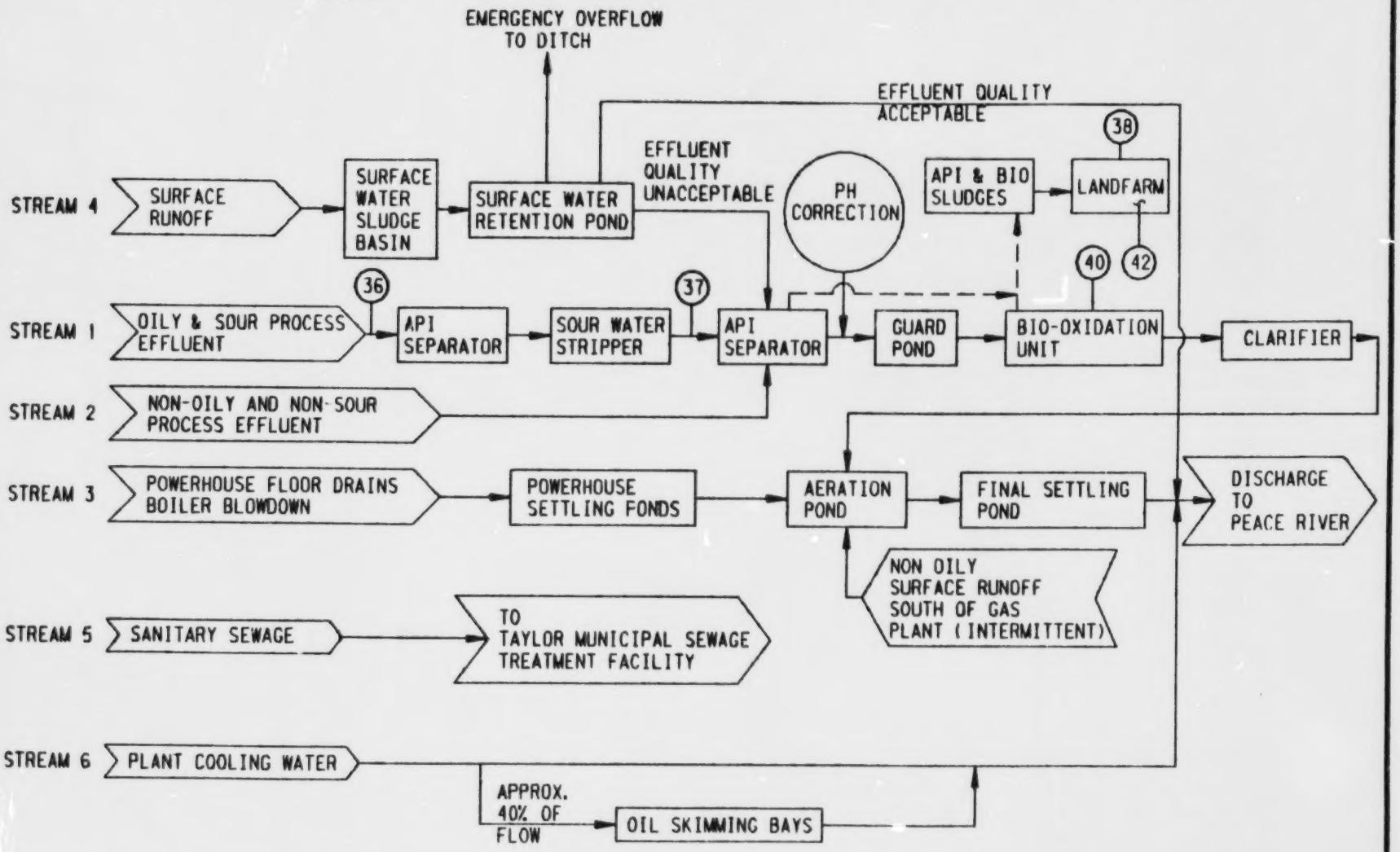

FIGURE 6-6

TAYLOR PLANT
SAMPLING LOCATIONS

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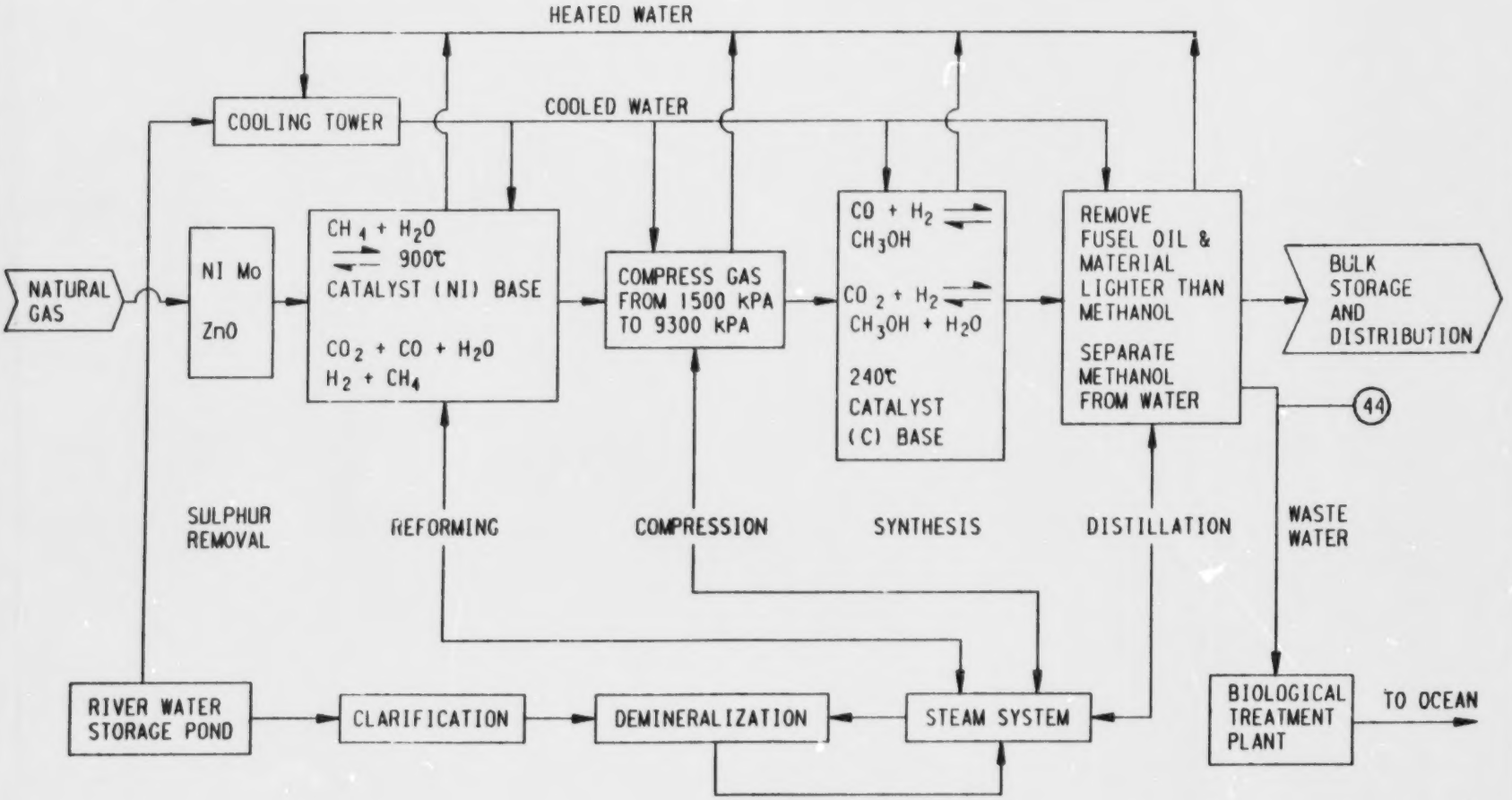

FIGURE 6-7
OCELOT CHEMICALS KITIMAT PLANT
SAMPLING LOCATIONS

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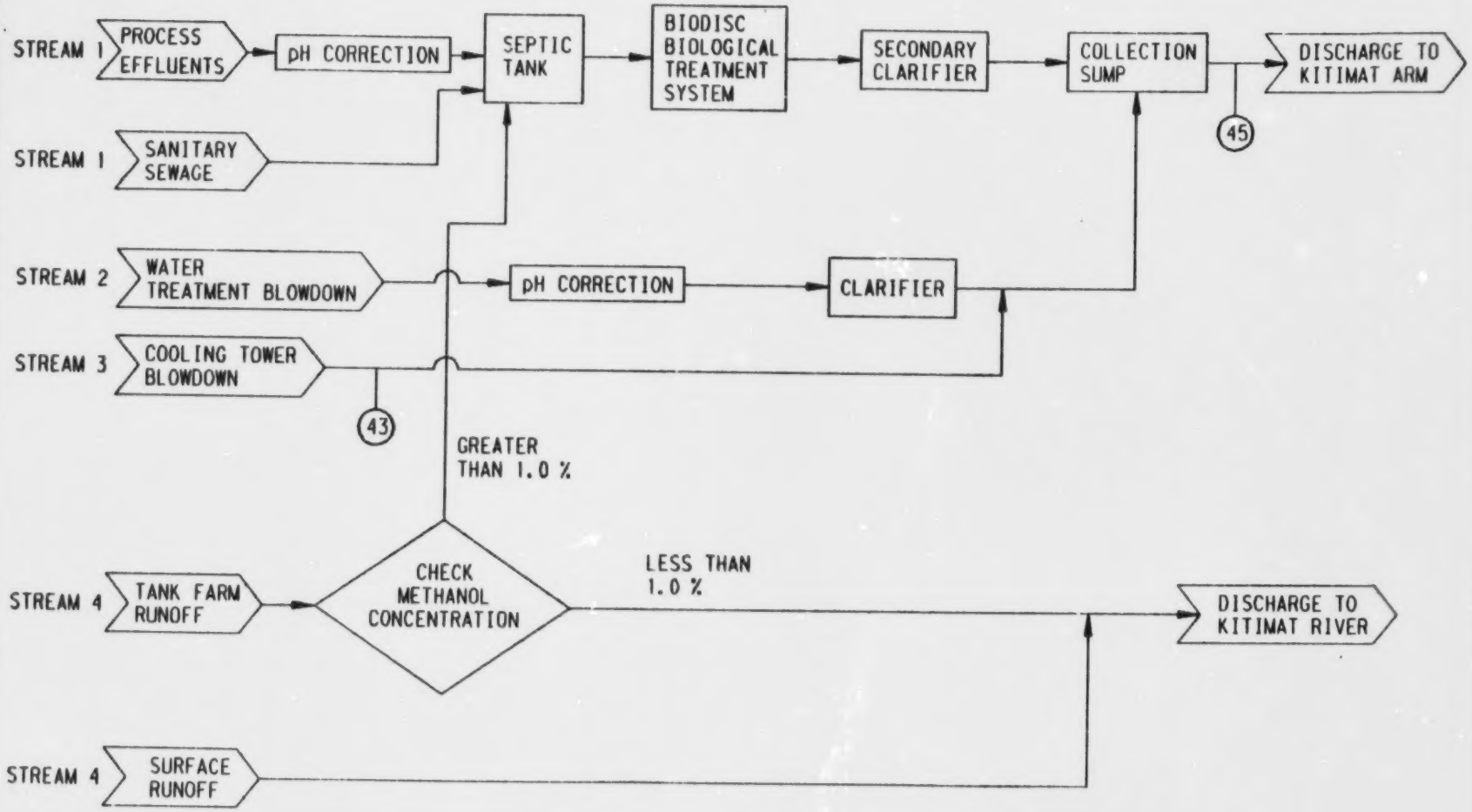

FIGURE 6-8
OCELOT CHEMICALS KITIMAT PLANT
SAMPLING LOCATIONS

N00514.CHT REV. 0

TABLE 6-1

Westcoast Transmission Fort Nelson Plant - Sampling Program

Liquid Effluents		Solid Wastes	
Sample No.	Waste Stream	Sample No.	Waste Stream
1.	Influent to activated sludge treatment plant	15.	Sludge from waste holding pond
4.	MEA reclaimer drain sludge	16.	Sludge from oil separation pond
5.	Process drains (from gas sweetening plant)	17.	Sludge from aeration lagoon
7.	Dehydration plant drains	19.	Spent dehydration process desiccants and spent sulphur conversion process catalysts.
8.	Sour water stripper and sulphur plant process drains		
11.	Boiler blowdown		
13.	Surface runoff		
14.	Final combined effluent discharge to Fort Nelson River		

TABLE 6-2

Westcoast Transmission Pine River Plant - Sampling Program

Liquid Effluents		Solid Wastes	
Sample No.	Waste Stream	Sample No.	Waste Stream
10.	Surface runoff	27.	Sludge from waste liquids holding pond
20.	Knock out drum liquids holding tank	28.	Sludge from waste water evaporation pond
21.	Sulfinol reclaimer bottoms	30.	Sludge from blowdown evaporation ponds
22.	Waste water treatment unit, aeration tank influent		
23.	Waste water treatment unit effluent		
24.	Boiler blowdown		
25.	Combined effluent for spray irrigation		

TABLE 6-3

Petro-Canada and Westcoast Transmission Taylor Plant - Sampling Program

Liquid Effluents		Solid Wastes	
Sample No.	Waste Stream	Sample No.	Waste Stream
34.	Gas treatment open drain	40.	bio sludge (landfarm)
36.	Influent to 1962 API separator	42.	Composite landfarm soil sample
37.	Influent to 1972 API separator		
38.	Landfarm runoff		

TABLE 6-4

Ocelot Chemicals Kitimat Plant - Sampling Program

Liquid Effluents	
Sample No.	Waste Stream
43.	Cooling tower blowdown
44.	Refining column blowdown
45.	Combined plant effluent

6.2.1 SAMPLING METHODOLOGY

All aqueous and solid waste samples were collected as single grab samples. Liquid effluents requiring analysis for conventional and inorganic contaminants were collected in high quality plastic bottles. Samples for trace element analyses were acidified but not filtered. Solid wastes (including sludges) were collected in polyethylene bottles or plastic bags for inorganic analysis. Samples, both liquid and solid, selected for complete organic analysis were duplicated and stored in glass bottles with teflon seals.

All samples were chilled and shipped to Monenco Analytical Laboratories (conventional and inorganic analyses) or Enviro-Test Laboratories (organic analysis) as soon as possible.

Waste stream flow rates were not measured as the facilities for measuring the flow rates were not available at the sites. The lack of data on wastewater flows are identified in Part 5 on data gaps.

6.3 ANALYTICAL PROGRAM

The analytical program for liquid and solid wastes is summarized in Table 6-5. All wastes were analyzed for conventional and inorganic parameters. Seven (7) samples, identified in Table 6-6, were submitted for detailed organic analyses.

Details of analytical procedures are provided in Appendix B.

TABLE 6-5

Analytical Program

Pollutants	Solid Wastes	Liquid Effluents
1. Conventional Pollutants	pH, hydrocarbon content, organic carbon, TKN, sulphides	pH, BOD, TOC, COD, hydrocarbon content, suspended and total solids, TKN, ammonia, nitrate, phenols, sulphate, sulphides, manganese, cyanide
2. Inorganic Pollutants	arsenic, barium, boron, cadmium, chromium, copper, manganese, mercury, nickel, lead, zinc	arsenic, barium, boron, cadmium, chromium, copper, mercury, nickel, lead, zinc

3. Organic Pollutants

Analytical methodology as follows:

- extraction procedure to isolate two major fractions (base/neutral fraction and acid fraction).
- both fractions analyzed by GC/MS (gas chromatography/mass spectrometry) and GC/FID (gas chromatography/flame ionization detection).
- acid/neutral fraction also analyzed using GC/ECD (gas chromatography/electron captive detection).
- two techniques were used to identify organic compounds:

(1) NBS library search/manual interpretation
- this is an automated software program which is potentially capable of identifying every compound which has been resolved (high resolution capillary column) and which is present at concentrations detectable by MS.

(2) Priority Pollutant Search
- this is an automated software program which specifically detects the U.S. Environmental Protection Agency (EPA) target organics. It is a very specific and sensitive method using selected ions for determination and quantification.

TABLE 6-6

Samples Selected for Organic Analysis

Plant	Sample No.	Waste Stream
1. Fort Nelson	1	Influent to activated sludge treatment plant
	14	Final combined effluent discharge
	15	Wastes holding pond sludge
2. Pine River	20	Knock out drum liquids holding tank
	25	Combined effluent for spray irrigation
3. Taylor	34	Gas treatment open drain
4. Kitimat	45	Combined plant effluent

PART 7

DISCUSSION OF RESULTS

PART 7 - DISCUSSION OF RESULTS

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7.1 INTRODUCTION

The results of analytical determinations for liquid and solid waste streams from the three sour gas processing facilities and a methanol plant are provided in the following sections on a plant-by-plant basis. It is emphasized that the purpose of the sampling and analytical program was to provide indications of the types of contaminants present in liquid and solid waste streams. Since only single grab samples were collected and analyzed, broad conclusions with respect to treatment efficiencies or compliance to discharge limits cannot be made.

Sources of contaminants in wastes from gas processing plants include:

- o organics and trace elements in feedstocks;
- o organics and trace elements in chemicals used in gas processing, and in lubricating oils for rotating equipment;
- o trace elements in chemicals used for treating boiler feedwater and cooling water;
- o corrosion products; and
- o trace elements in the raw water supply to the gas plants.

Analysis of sludge samples revealed presence of a variety of metals in the sludges. In most, if not all cases, the metal concentrations in the gas plant sludges were lower than the metal concentrations in Canadian refinery biosludges and Ontario municipal sewage sludges (Table 7-1). While the gas plant sludges are not directly comparable to the refinery or the municipal sewage sludges, Table 7-1

TABLE 7-1

Metal Concentrations of Canadian Refinery Biosludges
and Ontario Municipal Sewage Sludges[1]

Parameter	Concentration Unit[2]	Refinery Sludges[3]			Ontario Sewage Sludges		
		Min	Max	Mean	Min	Max	Mean
Cadmium	ppm Cd	1	15	5	3.4	256	57
Chromium	ppm Cr	22	8460	2099	32	8140	2330
Copper	ppm Cu	120	4320	968	236	5090	1400
Manganese	ppm Ma	60	240	135	220	2150	528
Mercury	ppm Hg	3	23	8	0.9	19	4.9
Lead	ppm Pb	24	510	227	57	3430	1400
Nickel	ppm Ni	60	300	130	20	2600	446
Zinc	ppm Zn	150	2660	1150	780	12360	4430

[1] PACE. Landspreading at Sludges of Canadian Petroleum Facilities. PACE Report No. 81-5A, 1981.

[2] Dry weight basis.

[3] Data not considered comprehensive by PACE.

gives an indication of the relative concentration of metals in refinery and municipal sludges.

The organic compounds detected in water and sludge samples represent a wide and diverse assemblage. Unfortunately, not all compounds could be attributed a specific structure or name. Where compounds could be identified by specific name and structure, their environmental significance was based on the known potential for biodegradability, concentration in the sample, toxicity, and the U.S.EPA designation.

This study is based on the analysis of only one sample from each waste stream and thus the results can only be indicative of the presence of potential compounds in the gas and methanol plant wastes.

7.2 FORT NELSON GAS PLANT

7.2.1 CONVENTIONAL AND INORGANIC POLLUTANTS

The range of concentrations of conventional and inorganic pollutants in aqueous streams at the Fort Nelson gas plant are presented in Table 7-2. The detailed analytical results for the aqueous samples taken at Fort Nelson are given in Appendix C. Table 7-2 shows that the pH of the aqueous streams at the Fort Nelson gas plant varies from 6.08 to 11.51, while sulphate varies from 2.0 to 775 mg/L and total Kjeldahl nitrogen varies from 0.15 to 378 mg/L. The results exhibit a broad range of BOD (58-1090 mg/L) and COD (18-2735 mg/L) value. The high suspended solids, ammonia, and total Kjeldahl nitrogen concentrations are thought to be a consequence of high nitrogen loading from amine solutions (MEA) and the activated sludge treatment plant.

The table also shows a low trace element levels in the aqueous streams.

TABLE 7-2

Fort Nelson Gas Plant
Range of Analytical Results[a] - Aqueous Samples

Parameter	Concentration Units	Concentration Range	
		Min	Max
pH		6.08	11.51
TSS	mg/L	2.0	244
Sulphide	mg/L S	0.6	15.4
Sulphate	mg/L SO_4	2.0	775
Nitrate	mg/L N	L0.03	0.97
Ammonia	mg/L N	L0.10	219
TKN	mg/L N	0.15	378
TOC	mg/L C	5	560
COD	mg/L O_2	18	2735
BOD	mg/L O_2	58	1090
Oil and Grease	mg/L	L0.2	16.8
Phenol	mg/L	L0.1	1.7
Arsenic	microg/L As	L20	120
Boron	mg/L B	0.02	0.38
Barium	mg/L Ba	L0.5	L1
Cadmium	mg/L Cd	L0.01	0.03
Chromium	mg/L Cr	L0.2	0.11
Copper	mg/L Cu	L0.02	L0.6
Cyanide	mg/L Cn	0.040	0.37
Mercury	microg/L Hg	L0.05	1.8
Manganese	mg/L Mn	L0.08	0.78
Nickel	mg/L Ni	L0.1	L5
Lead	mg/L Pb	L0.1	L5
Zinc	mg/L Zn	L0.5	1.01

[a] For a detailed listing of analytical results see Table C-1.

"L" signifies less than or equal to.

Table 7-3 presents the range of metals and inorganic parameters for sludges and solids from the Fort Nelson gas plant. All metals in Table 7-3 exhibit lower concentrations than those presented in Table 7-1. Some of the sludges exhibit high concentrations of sulphide and total Kjeldahal nitrogen.

7.2.2 ORGANIC POLLUTANTS

The results of analysis of organic pollutants in aqueous and sludge samples at the Fort Nelson gas plant are presented in Table 7-4. In the aqueous samples, the base/neutral fraction range from 0.09 to 0.77 ppm of total hydrocarbons. The unsubstituted aromatics, the aromatic nitrogen fractions and the phthalates are present in very low concentrations which make them easily accessible for biodegradation in any treatment system. The alkyl alcohol is also present in low concentration and is therefore amenable to biodegradation.

The acid fractions of the aqueous samples contain several substituted phenols and unidentified acids. At their present concentrations, they do not pose any environmental problems.

As is to be expected, the concentrations of organics in the lagoon sludge are several times those in the aqueous wastes. Of the five groups found in the base/neutral fraction, the paraffins and steroids as well as the long-chained alcohol (grouped with others) present no real environmental hazard at the concentrations present. However, nothing can be said of the three unidentified aromatics (totaling 85 ppm) and the other eight unidentified compounds (totaling 157 ppm) until more specific information about them is available.

TABLE 7-3

Fort Nelson Gas Plant
Range of Analytical Results[a] - Sludges and Solids

Parameter	Concentration Unit	Concentration Range		
		Sludges		
		Min	Max	Solids
pH		7.16	7.4	5.6
Oil	%	0.60	19.7	0.56
TKN	ppm N	2070	21070	1050
Barium	ppm Ba	166	205	58
Cadmium	ppm Cd	L2	L2	L2
Chromium	ppm Cr	11	28	65
Copper	ppm Cu	23	57	11
Manganese	ppm Mn	305	500	93
Nickel	ppm Ni	L25	45	30
Lead	ppm Pb	L25	L25	L25
Zinc	ppm Zn	116	225	56
Mercury	ppm Hg	0.13	0.75	0.04
Sulphide	ppm S	550	4030	1890
Arsenic	ppm As	7.8	9.0	7.5
Boron	ppm B	40	40	L0.5

[a] For a detailed listing of analytical results, see Table C-2.

"L" signifies less than or equal to.

TABLE 7-4

Fort Nelson Gas Plant
Analytical Results[a] - Organic Analyses

Fraction	Parameter	Concentration in ppm		
		Aqueous		Sludge
Base-neutral	Paraffins			690
	Alkyl Alcohol		0.05	
	Aromatics	0.17	0.04	85
	Aromatic Nitrogen	0.25		
	Phthalates	0.004		10
	Steroids			535
	Others	0.35	____	184
	Totals	0.77	0.09	1500
Acid	Phenols and Acids	0.243		80
	Alcohols			30
	Others	0.017	0.026	____
	Totals	0.26	0.026	110

[a] For a detailed listing of analytical results, see Tables C-3, C-4 and C-5.

The presence of Bis (2-ethylhexyl) phthalate at 10 ppm in the sludge is of concern in that it is an EPA priority pollutant and a carcinogen, although some argument has been expressed concerning its carcinogenic potential. It is one of the phthalic acid esters that is very resistant to microbial degradation. It may be the only compound of concern in the disposal of this sludge.

The acid fraction of the sludge contains long-chained acids and alcohols which are of no environmental concern in disposal of the sludge.

7.3 PINE RIVER GAS PLANT

7.3.1 CONVENTIONAL AND INORGANIC POLLUTANTS

Table 7-5 gives the range of concentration of conventional and inorganic parameters for aqueous samples from the Pine River gas plant. These results are of interest primarily as a qualitative analysis since the plant was shutdown for several days before the samples were collected. The results show a COD range of 29-513 000 mg/L. Examination of the detailed results presented in Appendix C shows that the maximum COD value results from the knockout drum liquids holding tank. Closer examination of the COD values shows that the final effluent to spray irrigation has a much lower COD concentration (35 mg/L). The intermediate high value of 6740 mg/L of COD in the effluent is considered to be an indication of transient conditions associated with the plant shutdown.

The concentrations of other parameters do not raise significant concerns from a qualitative viewpoint.

Table 7-6 provides the range of concentration for the sludges at the Pine River gas plant. The sludges have TKN ranging from

TABLE 7-5

Pine River Gas Plant
Range of Analytical Results[a] - Aqueous Samples

Parameter	Concentration Units	Concentration Range	
		Min	Max
pH		6.10	11.50
TSS	mg/L	1.6	2080
Sulphide	mg/L S	0.4	17.3
Sulphate	mg/L SO_4	18	538
Nitrate	mg/L N	L0.03	0.75
Ammonia	mg/L N	L0.10	15
TKN	mg/L N	1.09	282
TOC	mg/L C	8	1200
COD	mg/L O_2	29	513000
BOD	mg/L O_2	-	6
Oil and Grease	mg/L	L0.2	3156
Phenol	mg/L	L0.1	0.6
Arsenic	microg/L As	L20	100
Boron	mg/L B	0.08	9.23
Barium	mg/L Ba	L0.005	2.0
Cadmium	mg/L Cd	L0.01	0.03
Chromium	mg/L Cr	L0.2	0.4
Copper	mg/L Cu	L0.015	1.27
Cyanide	mg/L Cn	0.002	19
Mercury	microg/L Hg	L0.05	0.31
Manganese	mg/L Mn	0.03	4.9
Nickel	mg/L Ni	L0.1	1.2
Lead	mg/L Pb	L0.1	0.2
Zinc	mg/L Zn	L0.01	0.46

[a] For a detailed listing of analytical results see Table C-6.

"L" signifies less than or equal to.

TABLE 7-6

Pine River Gas Plant
Range of Analytical Results[a] - Sludge Samples

Parameter	Concentration Units	Concentration Range	
		Min	Max
pH		6.59	7.13
Oil	%	0.18	9.0
TKN	ppm N	500	2240
Barium	ppm Ba	314	400
Cadmium	ppm Cd	L2	L2
Chromium	ppm Cr	8	25
Copper	ppm Cu	13	25
Manganese	ppm Mn	98	285
Nickel	ppm Ni	L25	L25
Lead	ppm Pb	L25	115
Zinc	ppm Zn	73	108
Mercury	ppm Hg	0.06	0.56
Sulphide	ppm S	L150	530
Arsenic	ppm As	L1.0	5.8
Boron	ppm B	50	60

[a] For a detailed listing of analytical results, see Table C-7.

"L" signifies less than or equal to.

500-2240 ppm N and barium and manganese ranging from 314-400 mg/L Ba and 98-285 mg/L Mn respectively. In all cases, the metal concentrations are well below the metal concentrations in the Canadian refinery biosludges and Ontario Municipal sewage sludges (Table 7-1).

7.3.2 ORGANIC POLLUTANTS

The base/neutral fraction of the aqueous wastes from the Pine River gas plant contains a large concentration of long-chained alkanes and branched alkanes totaling 515 ppm (Table 7-7). Available information on tests with rainbow trout show that this level is well below the concentrations producing detrimental chronic impacts on trouts.

The polycyclic aromatic hydrocarbons in the base/neutral fraction consists of several dimethyl naphthalenes (totaling 161 ppm) and trimethyl naphthalenes (totaling 134 ppm). These concentrations are acutely toxic to aquatic organisms. The C_4-naphthalene has the potential (at 4 ppm) to be acutely toxic to at least some aquatic fauna.

Of the three polycyclic aromatic hydrocarbons which are EPA priority pollutants (naphthalene, acenaphthene, and phenanthrene), only phenanthrene occurs in concentrations which are potentially toxic to aquatic fauna. The methyl and dimethyl benzothiaphenes present in the aqueous samples also occur in concentrations which would be acutely or chronically toxic to most aquatic fauna.

There is insufficient information available to determine the impact of the large concentrations of steroidal-type compounds and the acids in the acid fraction of the aqueous samples.

No information is available on the environmental fate and effect of pentathrepane. However, based on its structure (a ring composed of five sulphur and two carbon atoms), it should be

TABLE 7-7

Pine River Gas Plant
Analytical Results[a] - Organic Analyses

Fraction	Parameter	Concentration in ppm	
		Aqueous	
Base-neutral	Paraffins	515	
	Polycyclic Aromatics	335	
	Benzothiophenes	26	
	Steroids	223	
	Substituted Morphaline or Cyclic Nitrogen Compounds	___	0.38
	Total	1100	0.38
Acid	Substituted Morpholine or Cyclic Nitrogen Compounds		0.14
	Acids	80	
	Others	30	___
	Total	110	0.14

[a] For a detailed listing of analytical results, see Tables C-8 and C-9.

biodegradable. The phenanthrene derivative at 20 ppm has the potential to be toxic to aquatic fauna based on the toxicity of its parent compound.

7.4 TAYLOR PLANT

7.4.1 CONVENTIONAL AND INORGANIC POLLUTANTS

Results of analysis (range) of aqueous samples from the Taylor Plant for conventional and inorganic parameters are provided in Table 7-8. Because the Taylor Plant has a waste management system in which gas plant and refinery wastes are not segregated, three of the four samples taken cannot be considered wholly characteristic of gas plant waste waters. The analysis shows that stream pH vary from 6.88 to 12.43. Some of the streams contains significant amounts of nitrogen and organic carbon, presumably due to amine treatment.

Of the metals analyzed in aqueous samples, none were measured in concentrations which give rise to concerns.

Table 7-9 presents results from the analysis of sludge and solid samples. The sludge has a high total Kjeldahl nitrogen content (63500 ppm) and slightly elevated metal concentrations compared to the other gas plant sludges. However in all cases, the metals are below the metal concentrations of the Canadian refinery biosludges and Ontario municipal sewage sludges (Table 7-1).

7.4.2 ORGANIC POLLUTANTS

The sample from the open drain in the gas treatment section (Sample 34) was analyzed for its organic content. A summary of the

TABLE 7-8

Taylor Gas Plant
Range of Analytical Results[a] - Aqueous Samples

Parameter	Concentration Units	Concentration Range	
		Min	Max
pH		6.88	12.43
TSS	mg/L	1.2	188
Sulphide	mg/L S	1.5	292
Sulphate	mg/L SO_4	37	838
Nitrate	mg/L N	L0.03	0.13
Ammonia	mg/L N	L0.10	204
TKN	mg/L N	2.35	670
TOC	mg/L C	19	700
COD	mg/L O_2	107	3050
Oil and Grease	mg/L	L0.2	6.6
Phenol	mg/L	L0.1	10.4
Arsenic	microg/L As	L20	L20
Boron	mg/L B	0.05	0.27
Barium	mg/L Ba	L0.5	L0.5
Cadmium	mg/L Cd	L0.1	L0.1
Chromium	mg/L Cr	L0.2	L0.2
Copper	mg/L Cu	L0.02	0.03
Mercury	microg/L Hg	L0.05	0.21
Manganese	mg/L Mn	L0.01	0.39
Nickel	mg/L Ni	L0.1	L0.1
Lead	mg/L Pb	L0.1	L0.3
Zinc	mg/L Zn	0.06	0.20

[a] For a detailed listing of analytical results see Table C-10.

"L" signifies less than or equal to.

TABLE 7-9

Taylor Gas Plant
Analytical Results[a] - Inorganic Analysis of Sludges

Parameter	Concentration Unit	Samples[a]	
		Sludge	Solid
pH		6.91	7.15
Oil	%	10.1 ± 0.1	4.3 ± 0.1
TKN	ppm N	63500 ± 7000	5230 ± 500
Barium	ppm Ba	850 ± 100	288 ± 10
Cadmium	ppm Cd	23 ± 2	L2
Chromium	ppm Cr	62 ± 5	31 ± 5
Copper	ppm Cu	115 ± 4	109 ± 4
Manganese	ppm Mn	132 ± 5	380 ± 10
Nickel	ppm Ni	35 ± 25	55 ± 25
Lead	ppm Pb	119 ± 25	L25
Zinc	ppm Zn	465 ± 25	188 ± 25
Mercury	ppm Hg	1.81 ± 0.12	0.22 ± 0.02
Sulphide	ppm S	L600	950 ± 150
Arsenic	ppm As	6.5 ± 0.5	28.2 ± 2.5
Boron	ppm B	50 ± 10	-

[a] For a detailed listing of analytical results, see Table C-11.
'L' signifies less than or equal to

results is provided in Table 7-10. The base/neutral fraction of this sample contained only 1.5 ppm total hydrocarbons. The long-chained alkanes (paraffins) are no environmental concern. The substituted phenols are also of no environmental concern due to their low concentration and the ease with which the main phenol component is degraded in the natural acclimatized environment. While two of the three polycyclic aromatic hydrocarbons are EPA priority pollutants, they are present in concentrations well below acutely toxic levels for aquatic fauna. Both compounds (naphthalene and phenanthrene) are known to be degraded (albeit slowly) by naturally occurring microorganisms. As such, all three polycyclic aromatic hydrocarbons are of no concern at the given concentration.

The remaining compounds in the base/neutral fraction appear innocuous in terms of their environmental fate and effect at the given concentrations. The possible exception to this would be the Benzene diamine and aromatic amines. The latter have long been recognized as chemical carcinogens.

The paraffins and the substituted phenols in the acid fraction are similar to those identified in base/neutral fraction. The remaining compounds in the acid fraction (listed under "Others") appear to be of little environmental concern based either on their composition as a long-chained alcohol or their low concentration.

7.5 KITIMAT METHANOL PLANT

Results of analyses from sampling of aqueous waste streams from the methanol plant are provided in Table 7-11 (Conventional and Inorganic Pollutants) and Table 7-12 (Organic Analyses). The pH of the aqueous samples vary from pH 7.03 to pH 10.24 while the TSS vary from 1.0 to 71.5 mg/L. Detailed analysis of the results (Appendix C) show that both

TABLE 7-10

Taylor Gas Plant
Analytical Results[a] - Organic Analyses

Fraction	Parameter	Concentration in ppm
		Aqueous
Base-neutral	Paraffins	0.82
	Phenols	0.57
	Polycyclic Aromatics	0.017
	Others	0.094
	Total	1.5
Acid	Paraffins	0.46
	Phenols	0.38
	Others	0.26
	Total	1.1

[a] For a detailed listing of analytical results, see Table C-12.

TABLE 7-11

Kitimat Methanol Plant
Range of Analytical Results[a] - Aqueous Samples

Parameter	Concentration Units	Concentration Range	
		Min	Max
pH		7.03	10.24
TDS	mg/L	86	614
TSS	mg/L	1.0	71.5
Sulphate	mg/L SO_4	L2	290
Sulphide	mg/L S	L0.2	0.8
Nitrate	mg/L N	L0.05	0.36
Ammonia	mg/L N	L0.10	1.1
TKN	mg/L N	0.27	1.50
TOC	mg/L C	11	41
COD	mg/L O_2	44	122
Oil and Grease	mg/L	L1	3
Phenol	mg/L	L0.1	0.2
Arsenic	microg/L As	L10	L10
Boron	mg/L B	0.6	1.8
Barium	mg/L Be	L0.1	L0.1
Cadmium	mg/L Cd	L0.01	L0.01
Chromium	mg/L Cr	L0.04	0.08
Copper	mg/L Cu	L0.02	0.05
Mercury	microg/L Hg	L0.08	0.83
Manganese	mg/L Mn	L0.01	0.06
Nickel	mg/L Ni	L0.04	0.06
Lead	mg/L Pb	L0.04	0.06
Zinc	mg/L Zn	L0.02	L0.02

[a] For a detailed listing of analytical results see Table C-13.

"L" signifies less than or equal to.

TABLE 7-12

Kitimat Methanol Plant
Analytical Results[a] - Organic Analyses

Fraction	Parameter	Concentration in ppm
		Aqueous
Base-neutral	Paraffins	7.2
	Polycyclic Aromatic Hydrocarbons	less than 0.001
	Totals	7.2
Acid	Paraffins	2.7
	Totals	2.7

[a] For a detailed listing of analytical results, see Table C-14.

the TSS and sulphide levels in the effluent are in excess of the discharge limits.

The stright-chained and branched alkanes in the aqueous sample pose no toxic potential to aquatic fauna or flora, either singly or in combination. These compounds are easily biodegraded at the concentrations observed, especially by acclimated microflora. The single polycyclic aromatic hydrocarbon (naphthalene) identified in the sample is an EPA priority pollutant. It is present at less than 1 ppb and poses no environmental concern.

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APPENDIX A

NATURAL GAS AND NATURAL GAS PROCESSING

APPENDIX A

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A-1 Typical Over-all Gas Processing Scheme A-5

A.1 NATURAL GAS

Natural gas from underground reservoirs contains large quantities of methane as well as much smaller quantities of heavier hydrocarbons (ethane, propane, isobutane, etc.) and varying amounts of non-hydrocarbons (nitrogen, hydrogen sulphide, carbon dioxide, etc.). Table A-1 (Younger 1983) lists typical raw gas compositions for a number of Western Canadian wells.

Before gas can be used for commercial purposes a number of the impurities must be removed. Tables A-2 and A-3 (Younger 1983) show the chemical composition for a typical gas intended for use as industrial fuel gas. To this end, gas processing facilities remove the acid gases (H_2S, CO_2), free liquids (hydrocarbon and water) and mercaptans (CH_3SH - methyl mercaptan or C_2H_5SH - ethyl mercaptan) from the raw gas stream.

A.2 GAS PROCESSING FACILITIES

A21 GENERAL

The exact process by which raw gas is transformed to saleable or residue gas is a function of many variables, the most important of which are H_2S content, hydrocarbon content, gas quantity, required sulphur recovery and economics. The basic scheme by which most gas is processed into a material having the specifications described in Tables A-2 and A-3 is illustrated in Figure A-1 (Younger 1983).

TABLE A-1

Typical Raw Gas Compositions

Field	Fox Creek	Ft. St. John B.C.	Carstairs	East Calgary	Kaybob South	Medicine Hat Shallow Gas
Geological Era	Mesozoic	Mesozoic	Paleozoic	Paleozoic	Paleozoic	Mesozoic
Period Formation	Cretaceous	Triassic	Mississippi	Devonian	Devonian	Cretaceous
Name	Viking	Baldonell	Elkton	Crossfield (D-1)	Beaver Hill Lake (D-3)	Medicine Hat
Component	Mole Percent					
N_2 (Nitrogen)	0.84	0.32	0.45	2.13	0.94	2.2
H_2S (Hydrogen sulphide)	0.00	4.37	0.62	29.12	17.89	-
CO_2 (Carbon Dioxide)	0.57	2.41	5.94	13.77	3.49	-
C_1 (Methane)	87.64	85.34	31.61	54.40	56.53	96.5
C_2 (Ethane)	5.61	4.50	6.74	0.35	7.69	1.2
C_3 (Propane)	2.97	1.50	2.31	0.12	3.38	0.1
IC_4 (Isobutane)	0.44	0.25	0.49	0.01	0.87	-
nC_4 (Normal butane)	0.81	0.48	0.70	0.04	1.73	-
IC_5 (Isopentane)	0.26	0.15	0.24	0.00	0.71	-
nC_5 (Normal pentane)	0.24	0.21	0.23	-	0.76	-
C_6 (Hexane)	0.25	0.47+	0.21	-	1.48	-
C_7 (Heptane+)	0.37	-	0.46	-	4.53	-

TABLE A-2

Typical Pipeline Gas Composition

	From a Field Plant[a] Mole %	From a Straddle Plant[b] Mole %
N_2	0.30	0.35
C_1	91.63	98.60
C_2	5.72	1.05
C_3	1.63	—
iC_4	0.29	—
nC_4	0.31	—
iC_5	0.12	—

a A Field Plant processes raw gas from a gas field, producing sales gas.

b A Straddle Plant processes sales gas from a Field Plant, removing the LPG fraction.

TABLE A-3

Typical Pipeline Gas Specifications

Specification Item	TransCanada	Alberta & Southern	Westcoast for US Use	Westcoast for For BC Use	Canadian Western
Minimum Heating Value BTU/CF	950	975	1000	1000	950
Hydrocarbon Dewpoint °F	15 @ 800 psia	15 @ 800 psia	Free from Liquids	Free from Liquids	15 @ 500 psia
Water Content lbs/MMSCF	4	4	4	4	Equivalent to 15°F dew-point @ 500 psig
H_2S content grains per 100 CF	1	0.25	0.25	1	1
Mercaptan content grains/100 CF	no spec	0.20	5.0	No spec	No spec
Total Sulphur grains/100 CF	20	1.0	20	20	10
CO_2 content Volume %	2	2	1	No spec	No spec
O_2 content Volume %	No spec	0.4	0.2	1	No spec
Delivery Temp Temp °F (max)	120	120	No spec	No spec	120
Delivery Press psig (max)	900	900	Varies	Varies	500

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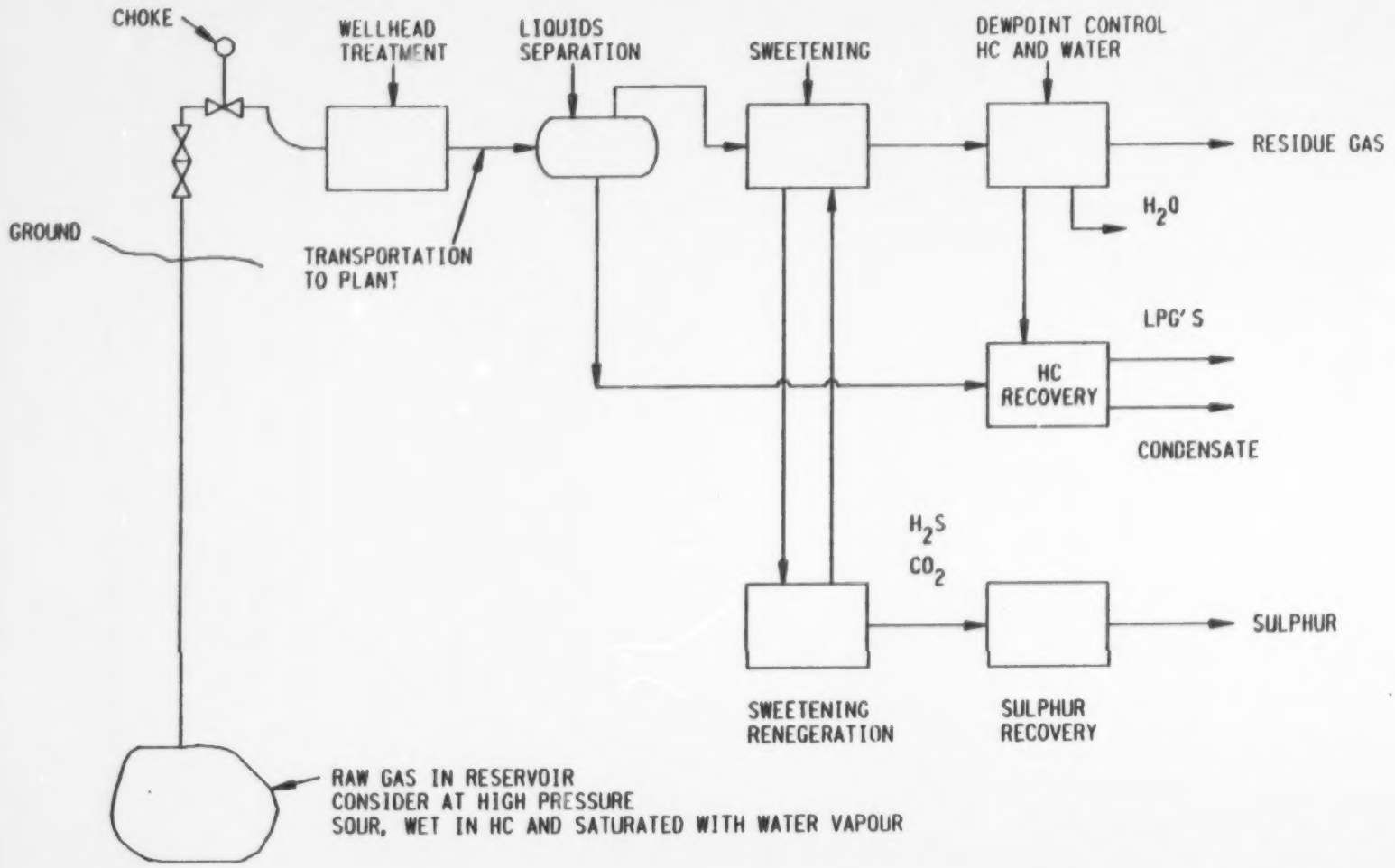

FIGURE A-1

TYPICAL OVERALL GAS PROCESSING SCHEME

N00514.CNT REV. 0

A22 SOUR GAS

Sour gas is generally defined as one having an H_2S content greater than 1 grain/100 CF (16 ppm) (Younger 1983). H_2S is a particularly toxic acid gas which forms sulphur dioxide (SO_2), an undesirable air contaminant, upon combustion. Hence it must be removed from the raw gas. Raw sour gas is converted to sweet residue and fuel gases, liquid petroleum gases (LPG's), condensate, and elemental sulphur using the following basic processes; liquid separation, sweetening, dewpoint control, LPG recovery, and sulphur recovery.

.1 Liquids Separation

Raw gas to a processing facility usually enters as a two phase fluid. The function of the inlet separators is to separate the gas and liquid (hydrocarbon and water) phases. The water removed from the inlet separator in this process is referred to as 'produced' or 'formation' water.

.2 Sweetening

The plant sweetening facilities are used to remove the acid gases (H_2S and CO_2). Table A-4 (Younger 1983) lists a number of the commercially available gas sweetening processes. Some of the more commonly used processes are described below.

.21 Amine Treating

The two amines which are most extensively used for acid gas stripping are monoethanolamine (MEA) and diethanolamine (DEA). In the MEA process sour gas at high pressure is fed to an absorbing tower where it is contacted with a 15 to 20 percent aqueous solution of MEA. The acid gas is absorbed by the amine and the remaining sweet gas exits from the top of the absorber.

TABLE A-4

Commercial Gas Sweetening Processes

Type	Process	Solvent/Packing
Chemical Solvent		
	MEA	2.5 N-Monoethanolamine (=15% in water)
	UCAR	5 N-Monoethanolamine (=30%) with inhibitor
	DEA	2 N-Diethanolamine (=21%)
	SNPA-DEA	3 N-Diethanolamine (=32%)
	DIPA	2 N-Diisopropanolamine (=27%)
	MDEA	2 N-Methyldiethanolamine (=24%)
	DGA (Econamine)	6 N-Diglycolamine (=63%)
	Catacarb	pot.carb.sol'n with catalyst
	Benfield	pot.carb.sol'n with catalyst
	Giammarco-Vetrocoke	pot.carb.sol'n + arsenic trioxide
	Alkacid-M	pot.salt of methyl amino propionic acid
	Alkacid-DIK	pot.salt of dimethyl amino acitic acid
Physical solvent		
	Selexol	Dimethyl ether of polyethylene glycol (DMPEG)
	Fluor solvent	Propylene carbonate
	Purisol	N-methyl-pyrrolidone (NMP)
	Rectisol	Methanol
	Sepasolv MPE	Oligoethylene glycol methyl isopropyl ethers
	Sulfinol	Mixture of sulfolane, DIPA and H_2O
	Amisol	Mixture of MEA, DEA with methanol
Direct conversion		
	Stretford	Sodium carbonate, sodium vanadate anthraquinone disulfonic acid and traces chelated iron
	Takahax	Sodium carbonate and 1,4 naphthoquinone, 2-sulfonate sodium
	Thylox	Sodium or ammonium thioarsenate sol'n
	Ferrox	Sodium carbonate and ferric hydroxide solution
	Manchester	Sodium carbonate and ferric hydroxide solution
	Perrox	Aqueous ammonia solution with hydroquinone
	Townsend	Triethylene glycol with dissolved SO_2
	Fugapol	Polyethylene glycol with metal salt catalyst
	G.V.-sulphur	Alkali arsenates and arsenites sol'n
Dry-bed		
	Iron sponge	Iron oxide
	Zinc oxide	Zinc oxide
	Mol. sieves	Molecular sieve
	Haines	Molecular sieve

The 'rich' amine is then led to a still and heated to remove the acid gases and regenerate the MEA. From here, the acid gases go to the sulphur plant and the MEA is cooled and recirculated back to the absorber.

Processes using diethanolamine (DEA) are generally very similar to those using MEA. DEA is often used with raw gas streams containing carbonyl sulphide (COS), a component commonly found in high H_2S gas streams. DEA does not react with COS while MEA does, forming undesirable nonregenerable compounds in the process.

.22 Hot Potassium Carbonate (K_2CO_3) Treating

The hot potassium carbonate treatment is most effective for acid gases which consist primarily of CO_2. Significant amounts of H_2S are usually removed in an additional amine clean up section. The process description is similar to that for MEA.

.23 Sulfinol Treating

The sulfinol process was developed by Shell Oil and uses a solvent which is a mixture of sulfolane, di-issopropanol amine (DIPA) and water. DIPA is a chemical absorbant which functions as the primary acid gas stripper. The sulfolane is a physical solvent which improves acid gas pick-up, particularly at high pressures. Again, the process flow description is similar to that for MEA.

.24 Iron Sponge Treatment

This process removes H_2S only by passing the gas through a bed of iron oxide and wood shavings. The resulting chemical reaction produces ferric sulphide and water. The bed is regenerated by passing air through it, which reacts with the sulphide and forms elemental sulphur

and returns the iron to the oxide. The process is normally used for raw gas streams with low H_2S content (ie. less than 50 grains/100 CF (800 ppm)) (Younger 1983).

.3 Dewpoint Control

The hydrocarbon dewpoint and water content requirements noted in Table A-3 are necessary to prevent the condensation of liquid hydrocarbons and water in pipelines transmitting gas to market or in the lines feeding consumers. Hence the raw gas must be dehydrated at the processing facility. Two processes, chilling with glycol addition and short cycle adsorption, are used to simultaneously meet the water content and hydrocarbon dewpoint specifications. In the first process, chilling with the gas is cooled to condense both the hydrocarbons and water while glycol is added to prevent the formation of hydrates and ice. The water, hydrocarbons, and glycol are then separated and the glycol reused. In the second process, short cycle adsorption, solid desiccants are used to adsorb the heavier hydrocarbon and water while passing the lighter hydrocarbons.

Two other processes, glycol dehydration and long cycle adsorption can be used for reduction of water content only. Finally, oil absorption can be used for treatment to meet the hydrocarbon dewpoint specification alone.

.4 LPG Recovery

If the propane and heavier content of raw gas exceeds about 0.6 U.S. gallons per 1000 CF, it may be economically viable to recover the heavier hydrocarbons (Younger 1983). There are various processes that can be used to separate the propane, butane, pentane and pentanes plus from the gas stream. These hydrocarbons are recovered in liquid form and then passed to distillation or fractionation facilities to separate the various products.

.5 Sulphur Recovery

In order to avoid excessive SO_2 concentrations in the air, the H_2S recovered in the sweetening process must be converted to elemental sulphur. This is most commonly accomplished by using the Modified Claus Process. In this process 1/3 of the H_2S is burned to SO_2 in a reaction furnace. The reaction for this step is as follows:

$$H_2S + 3/2O_2 \longrightarrow H_2O + SO_2$$

The products of this reaction are then cooled and the H_2S reacted with the SO_2 over a catalyst.

$$2H_2S + SO_2 \longrightarrow 2H_2O + 3\ S$$

The elemental sulphur formed is collected and stored in the liquid or solid phase.

The increasingly stringent requirements for the removal of SO_2 from stack emissions has led to the inclusion of sulphur plant tail gas clean-up processes in many gas processing facilities. Sulphur recovery efficiencies of up to 99 percent can be achieved with tail gas clean-up equipment operating in conjunction with conventional Claus recovery systems (Younger 1983). Extensive research has been conducted on stack SO_2 removal in many industries resulting in a number of commercially proven clean-up processes. Those that have been used or pilot tested in Western Canada include the following:

1. Sulfreen Process
2. Amoco CBA
3. IFP Process
4. Scot Process
5. Beavon

6. Pritchard Clean-Air
7. Wellman - Lord Process

Of these, perhaps the most common has been the Sulfreen Process which converts tail gas H_2S and SO_2 to sulphur by extension of the classic Claus reaction:

$$2H_2S + SO_2 \longrightarrow 3S + H_2O$$

A special activated alumina is used as adsorbent and catalyst in the reactors. The sulphur is recovered from the alumina adsorbent by heating with a flow of inert gas circulated by a blower. The gas is then cooled and the elemental sulphur condensed in a standard sulphur condenser. The recovery of sulphur in its elemental form rather than as sulphates is an advantage of this clean-up process particularly well suited to gas processing plants which already have sulphur handling facilities.

A23 SWEET GAS

Raw gas streams with less than 1 grain of H_2S/100 CF are usually considered to be sweet gas although some pipeline specifications may call for lower H_2S contents. The processing requirements for sweet gas are essentially the same as those for sour gas except that sweetening and sulphur recovery facilities are not required.

APPENDIX B

ANALYTICAL METHODS

APPENDIX B - ANALYTICAL METHODS

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B.1 INTRODUCTION

Inorganic and organic analyses were performed on the sludges and water samples collected at four British Columbia gas/chemical plants. Analytical methods are presented below.

B.2 INORGANIC ANALYSIS

The water samples were analyzed by the methods identified in Table B-1.

Sludge samples required some sample preparation before the analysis could be done. After extraction of hydrocarbons, the samples were air dried and then treated with a hot mixture of perchloric and nitric acids for four hours, cooled, made up to volume and filtered. The analysis were then performed on the liquid extract. The methods used for the analysis are presented in Table B-2.

B.3 ORGANIC ANALYSIS

B31 EXTRACTION PROCEDURES

The water samples are extracted according to method 625 (EPA). The sample 2L is transferred to a separatory funnel and extracted under basic conditions (pH 11-12, 6N NaOH) with 3X100 mL of methylene chloride. The organic extracts are combined and dried over sodium sulphate. This base/neutral fraction is then reduced to 1 to 2 mL using rotovap for concentration. The sample is quantitatively transferred to a

TABLE B-1

Analytical Methods for Aqueous Samples

Parameter	Method
pH	pH meter
Oil & Grease	NAQUADAT[a] 06521
TOC	NAQUADAT 16001
COD	NAQUADAT 08301
TSS	NAQUADAT 10451
TKN	NAQUADAT 07001
Ammonia	NAQUADAT 07506
Nitrate	NAQUADAT 07301
Phenol	NAQUADAT 06533
Sulphate	NAQUADAT 16306
Sulphide	Standard Methods[b]
Cyanide	NAQUADAT 06601
Manganese	Atomic Absorption
Arsenic	Hydride Generation-Atomic Absorption
Barium	Atomic Absorption
Boron	AECL Coulorimetric Technique
Cadmium	Atomic Absorption
Chromium	Atomic Absorption
Copper	Atomic Absorption
Mercury	Cold Vapour Atomic Absorption
Nickel	Atomic Absorption
Lead	Atomic Absorption
Zinc	Atomic Absorption

a Analytical Methods Manual, Environment Canada 1981.

b Standard Methods for the examination of Water and Wastewater.

TABLE B-2

Analytical Methods for Sludge Samples

Parameter	Method
pH	Saturated Paste
Oil Content	Volumetic-Extraction with Methylene Chloride
TOC	Potassium Dicromate/Acid Addition/Filtration
TKN	Macro-Kjeldahl Method
Sulphide	Oxidation/HCL digestion
Arsenic	Hydridge Generation-Atomic Absorption
Barium	Atomic Absorption
Baron	AECL Coulorimetric Technique
Cadmium	Atomic Absorption
Chromium	Atomic Absorption
Copper	Atomic Absorption
Manganese	Atomic Absorption
Mercury	Cold Vapour Atomic Absorption
Nickel	Atomic Absorption
Lead	Atomic Absorption
Zinc	Atomic Absorption

3.5 mL vial and reduced to a known volume using a gentle stream of nitrogen. The aqueous is made acidic (pH 1-2, 6N HCl) and extracted serially with 3x100 mL of methylene chloride thus resulting in an acid fraction. This fraction is dried and concentrated in the same fashion as the base/neutral fraction.

The sludge samples are shaken in acidic acetonitrile (pH 1-2, 6N HCl) 200 mL for 8 hours on a mechanical shaker. The sample is filtered and transferred to a separatory funnel. 300 mL of distilled water is added to the sample and the sample is made basic (pH 11-12, 6N NaOH) and extracted serially with 15% ether in hexane (3X60). The organic extracts are combined, dried over sodium sulphate and reduced to 1 to 2 mL using rotovap for concentration. The sample was then made up in exactly 10 mL. Further dilutions were made when required.

B32 TECHNIQUES USED IN GC/MS ANALYSIS

Two techniques are used to identify individual organic compounds.

.1 EPA Target Compound Analysis

This method uses extracted ion techniques and is very selective and sensitive. The analysis is automated by the use of a sophisticated GC/MS software program which searches, extracts, identifies and quantitates the target EPA organics. Quantitations of the EPA target compounds is <u>not</u> semi-quantitative as is the case for the non-target work. Every compound analyzed is run against a known calibration standard using the internal standard anthracene - D_{10}.

.2 Non-Target Identifications of Organics Using GC/MS - NBS Library Search Techniques and Manual Interpretation

This is a semi-automated method which is potentially capable of identifying every organic compound which has been resolved (high resolution capillary column) and which is present at concentrations detectable by mass spectrometry. This is a total ion technique and lacks the sensitivity achieved using the target compound selective ion technique. The final interpretation is done by the analyst who makes decisions regarding the accuracy of the library match (see table of confidence of identification of GC/MS spectra, Table B-3). Quantitation using this method is semi-quantitative only.

B33 GC/FID FOR FINGERPRINTING AND SEMI-QUANTITATION

Initial fingerprinting and semi-quantitation are achieved using GC/FID. Diesel oil is used as external standard to calculate a semi-quantitative total hydrocarbon content. Individual organics identified in the non-target GC/MS analysis are quantitated using a combination of percentage amount calculated by a specific GC/MS software program combined with the result obtained from the GC/FID analysis.

B34 LIST OF EPA PRIORITY POLLUTANTS ANALYZED

Detection limits apply for all of the water extraction (Table B-3).

B35 DETECTION LIMITS (APPROXIMATE)

- o Detection limit for EPA priority pollutants selected ion scan:
  - solids & sludges - .1 to .5 ppm;

TABLE B-3
EPA Priority Pollutant List
Compound Analysed By GC/MS, EPA Method 625

Base/Neutral	Detection Limit ppb, (ug/L)
Benzidine	5
Bis(2-chloroethyoxy)methane	5
Bis(2-chloroethyl)ether	5
Bis(2-chloroisopropyl)ether	5
Bis(2-ethylhexyl)phthalate	3
4-Bromophenyl phenyl ether	3
Butyl benzyl phthalate	3
2-Chloronaphthalene	3
4-Chlorophenyl phenyl ether	5
1,2-Dichlorobenzene	5
1,3-Dichlorobenzene	5
1,4-Dichlorobenzene	5
3,3'-Dichlorobenzidine	5
Dimethylphthalate	3
Diethylphthalate	3
Di-n-butylphthalate	3
2,4-Dinitrotoluene	3
2,6-Dinitrotoluene	3
1,2-Diphenylhydrazine	NR
Hexachlorobenzene	3
Hexachlorobutadiene	3
Hexachlorocyclopentadiene	3
Isophorone	3
Nitrobenzene	3
N-Nitrosodiphenylamine	10
N-Nitrosodimethylamine	10
N-Nitrosodi-n-propylamine	10
1,2,4-Trichlorobenzene	3

Phenols	Detection Limit ppb, (ug/L)
2-Chlorophenol	3
2,4-Dichlorophenol	3
2,4-Dimethylphenol	3
4,6-Dinitro-o-cresol	20
2,4-Dinitrophenol	20
2-Nitrophenol	20
4-Nitrophenol	20
P-Chloro-m-cresol	3
Pentachlorophenol	20
Phenol	3
2,4,6-Trichlorophenol	3

Polycyclic Aromatics	Detection Limit ppb, (ug/L)
Acenaphthene	3
Acenaphthylene	3
Anthracene	3
Benzo(a)anthracene or Chrysene	5
Benzo(k)fluoranthene or Benzo(b)fluoranthene	5
Benzo(a)pyrene	10
Fluoranthene	3
Fluorene	3
Naphthalene	3
Phenanthrene	3
Pyrene	3

Pesticides	Detection Limit ppb, (ug/L)
Aldrin	3
Alpha-BHC	3
Beta-BHC	3
Gamma-BHC	3
Delta-BHC	3
Chlordane	NR
4,4'-DDT	5
4,4'-DDE	5
4,4'-DDD	5
Dieldrin	3
Alpha-Endosulfan	3
Beta-Endosulfan	3
Endrin	3
Heptachlor	3
Heptachlor Epoxide	NR
PCB-1242	30
PCB-1254	30
PCB-1221	30
PCB-1232	30
PCB-1248	30
PCB-1260	30
PCB-1016	30

* Approximate detection limits are reported for aqueous samples.
* Detection limits for soils & sediments would be greater by an approximate factor of 10.
* NR - Not run at present.

- o Detection limit for general non-target organics: - solids & sludes - 1 to 2 ppm; and

- o Water - see Table B-3.

B36 QUALITY CONTROL

Blanks: Method blanks are analyzed along with the samples. Compounds present in the method blanks are subtracted when detected in actual samples.

B37 COMMENTS

- o Oil and Grease test compared to total extractables detected by GC/FID:

Oil and Grease is a gravametric test (weight) which results in the measurement of the total extractable hydrocarbons. The GC/FID semi-quantitative analysis measures only those hydrocarbons which are resolved by a chromatographic column. The two tests may not correlate exactly and in most cases the oil and grease test will result in a higher result; and

- o Raw Mass Spectra are available upon request.

APPENDIX C

DETAILED ANALYTICAL RESULTS

APPENDIX C - DETAILED ANALYTICAL RESULTS

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Conventional and Inorganic Pollutants in Aqueous Samples

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Organic Analysis of Process Water

C.1 FORT NELSON GAS PLANT

TABLE C-1

Analytical Results - Fort Nelson Gas Plant
Conventional and Inorganic Pollutants in Aqueous Samples

Parameter	Concentration Units		Samples[a]							
			1	4	5	7	8	11	13	14
pH			7.20 ± 0.01		7.99 ± 0.01	6.08 ± 0.01	10.02 ± 0.01	11.51 ± 0.01	8.30 ± 0.01	7.64 ± 0.01
TSS	mg/L				204 ± 10	2.0 ± 0.2	7.0 ± 0.4	35 ± 2	224 ± 11	85 ± 4
Sulphide	mg/L	S	15.4 ± 2		7.7 ± 0.2	1.6 ± 0.2	0.9 ± 0.2	2.9 ± 0.2	0.6 ± 0.2	1.6 ± 0.2
Sulphate	mg/L	SO_4	270 ± 5		85 ± 4	L 2.0	23 ± 1	775 ± 15	303 ± 10	320 ± 10
Nitrate	mg/L	N	L[b] 0.03		L 0.03	L 0.05	0.26 ± 0.03	0.97 ± 0.03	L 0.03	L 0.03
Ammonia	mg/L	N	22 ± 1		219 ± 5	L 0.10	L 0.10	L 0.10	73 ± 2	136 ± 5
TKN	mg/L	N	38 ± 1		378 ± 1	0.15 ± 0.05	04.0 ± 0.05	1.67 ± 0.05	133 ± 1	182 ± 1
TOC	mg/L	C	50 ± 10		560 ± 50	59 ± 2	5 ± 2	29 ± 2	260 ± 10	100 ± 10
COD	mg/L	O_2	281 ± 5		2735 ± 50	210 ± 5	18 ± 1	122 ± 2	1230 ± 20	496 ± 10
BOD	mg/L	O_2			1090 ± 75					58 ± 2
Oil and Grease	mg/L		3.8 ± 0.2		3.2 ± 0.2	16.8 ± 0.2	L 0.2	L 0.2	L 0.2	L 0.2
Phenol	mg/L		0.3 ± 0.1		0.4 ± 0.1	1.7 ± 0.1	L 0.1	0.6 ± 0.1	0.2 ± 0.1	0.2 ± 0.1
Arsenic	microg/L	As	L 20	120 ± 10	L 20	L 20	L 20	L 20	L 20	L 20
Boron	mg/L	B	0.20 ± 0.01		0.38 ± 0.01	0.04 ± 0.01	0.02 ± 0.01	0.12 ± 0.01	0.37 ± 0.01	0.15 ± 0.01
Barium	mg/L	Ba	L 0.5	L 1	L 0.5	L 0.5	L 0.5	L 0.5	L 0.5	L 0.5
Cadmium	mg/L	Cd	L 0.01	L 0.3	0.03 ± 0.01	L 0.01	L 0.01	L 0.01	L 0.01	L 0.01
Chromium	mg/L	Cr	L 0.2	L 0.6	0.4 ± 0.1	L 0.2	L 0.2	L 0.2	L 0.2	L 0.2
Copper	mg/L	Cu	L 0.02	L 0.8	0.09 ± 0.02	0.11 ± 0.02	L 0.02	L 0.02	0.07 ± 0.02	L 0.02
Cyanide	mg/L	CN			0.37 ± 0.02					0.040 ± 0.002
Mercury	microg/L	Hg	0.47 ± 0.05	0.44 ± 0.20	0.54 ± 0.05		L 0.05	0.11 ± 0.05	L 0.05	1.8 ± 0.1
Manganese	mg/L	Mn	0.29 ± 0.01	L 0.08	0.66 ± 0.01		0.06 ± 0.01	0.08 ± 0.01	0.78 ± 0.01	0.34 ± 0.01
Nickel	mg/L	Ni	L 0.1	L 5	0.3 ± 0.1	L 0.1	L 0.1	L 0.1	0.2 ± 0.1	L 0.1
Lead	mg/L	Pb	L 0.1	L 5	0.2 ± 0.1	L 0.1	L 0.1	L 0.1	L 0.1	L 0.1
Zinc	mg/L	Zn	0.14 ± 0.01	L 0.5	1.01 ± 0.01	0.34 ± 0.01	0.06 ± 0.01	0.05 ± 0.01	0.61 ± 0.01	0.20 ± 0.01

[a] see Table 6-1 for description of sample numbers
[b] 'L' signifies less than or equal to

TABLE C-2

Analytical Results - Fort Nelson Gas Plant
Inorganic Analysis of Sludges and Solid

Parameter	Concentration Unit	Sludge Samples[a]			Solid
		15	16	17	19
pH		7.4	7.23	7.16	5.6
Oil	%	0.60 ± 0.01	19.7 ± 0.1	3.4 ± 0.1	0.56 ± 0.01
TKN	ppm N	2440 ± 50	2070 ± 300	21070 ± 1500	1050 ± 50
Barium	ppm Ba	205 ± 10	186 ± 10	166 ± 10	58 ± 10
Cadmium	ppm Cd	L[b]2	L2	L2	L2
Chromium	ppm Cr	11 ± 5	18 ± 5	28 ± 5	65 ± 5
Copper	ppm Cu	23 ± 4	57 ± 4	42 ± 4	11 ± 4
Manganese	ppm Mn	305 ± 10	500 ± 10	360 ± 10	93 ± 5
Nickel	ppm Ni	L25	45 ± 25	L25	30 ± 25
Lead	ppm Pb	L25	L25	L25	L25
Zinc	ppm Zn	116 ± 3	225 ± 25	185 ± 25	56 ± 3
Mercury	ppm Hg	0.13 ± 0.02	0.53 ± 0.02	0.75 ± 0.02	0.04 ± 0.02
Sulphide	ppm S	550 ± 150	1200 ± 300	4030 ± 1000	1890 ± 800
Arsenic	ppm As	8.8 ± 0.5	7.8 ± 0.5	9.0 ± 0.5	7.5 ± 0.5
Boron	ppm B	40 ± 10	40 ± 10	40 ± 10	L0.5

[a] See Table 6-1 for description of sample numbers
[b] 'L' signifies less than or equal to

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TABLE C-3

Analytical Results - Fort Nelson Gas Plant

Organic Analysis of Influent to
Treatment Plant (Sample #1)

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #1 Influent to Treatment Plant, Ft. Nelson, Water Sample

LAB SAMPLE #: 5-84-876-1, base/neutral fraction

CONCENTRATION: 0.77 ppm, total hydrocarbons, calculated against diesel standard, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Aromatics	.17	22
Aromatic Nitrogen Compounds	.25	32
Others (see list)	.35	45
Phthalates	.004	Less than 1

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
	AROMATICS		
1. Unidentified Aromatic MW 178	4	.010	Process Chemical
2. Unidentified Aromatic MW 198	4	.020	Process Chemical
3. Unidentified Aromatic MW 224	4	.015	Process Chemical
4. Unidentified Aromatic MW 240	4	.040	Process Chemical
5. Unidentified Aromatic MW 268	4	.030	Process Chemical
6. Unidentified Aromatic MW 300	4	.030	Process Chemical
7. Unidentified Aromatic MW 240	4	.025	Process Chemical

.....2/

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
AROMATIC NITROGENS			
1. Unidentified Aromatic Nitrogen MW 149	4	0.020	Process Chemical
2. Unidentified Aromatic Nitrogen MW 175	4	0.025	Process Chemical
3. Unidentified Aromatic Nitrogen MW 197	4	0.010	Process Chemical
4. Unidentified Aromatic Nitrogen MW 203	4	.075	Process Chemical
5. Unidentified Aromatic Nitrogen MW 203	4	0.84	Process Chemical
6. Unidentified Aromatic Nitrogen MW 257	4	.025	Process Chemical
7. Unidentified Aromatic Nitrogen MW 201	4	.010	Process Chemical
PHTHALATES			
1. Dibutyl phthalate	1	.002	
2. Butylbenzyl phthalate	1	.002	
OTHERS			
1. Unidentified Possible Carboxylic Acid	4	.250	
2. Unidentified Organic Compound	5	.106	

NOTE: Although specific compounds were not identified, the class of compound identifications are accurate. The bulk of the sample appears to be process chemical mixtures.

See GC/MS chromatogram, attached.

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #1 Influent to Treatment Plant, Ft. Nelson, Water Sample

LAB SAMPLE #: 5-84-876-1, acid fraction

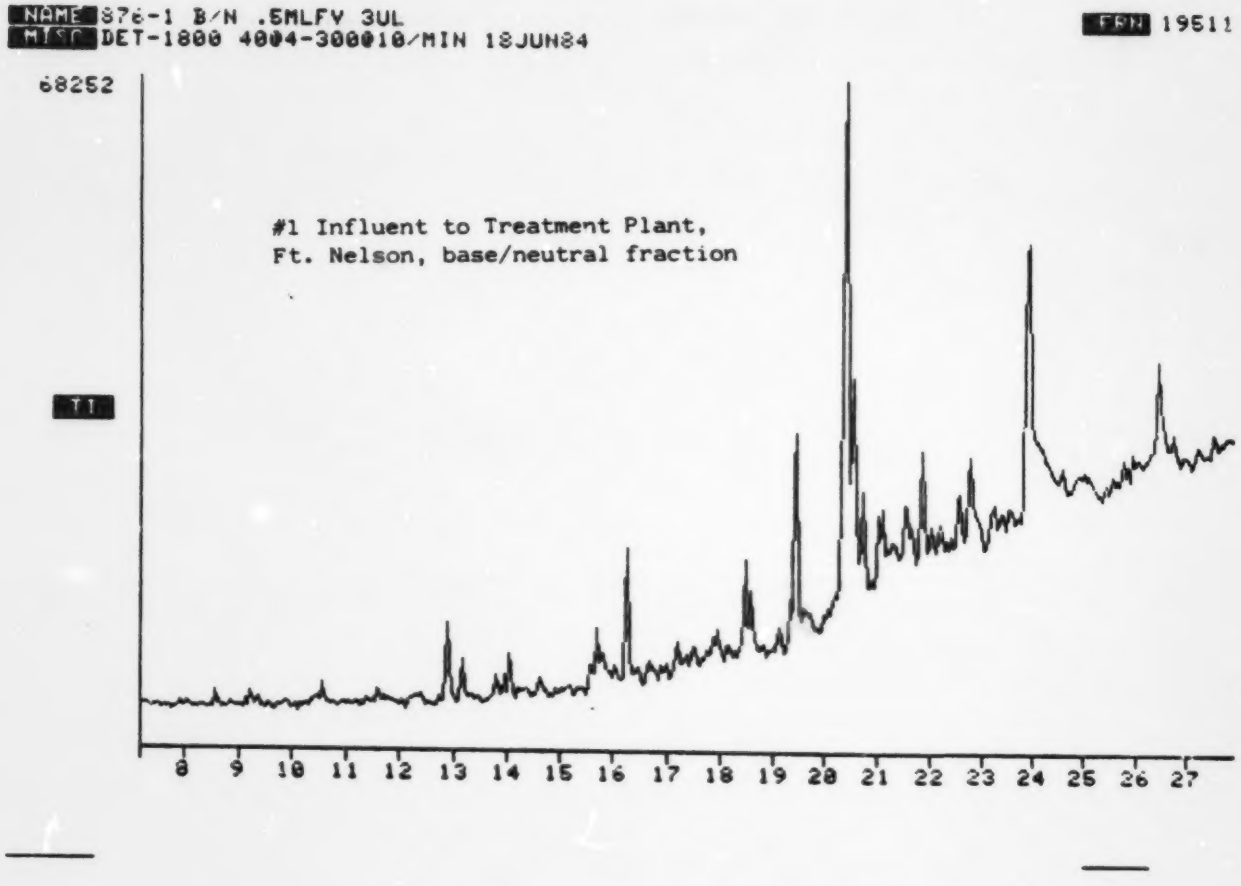
CONCENTRATION: 0.26 ppm, total hydrocarbon, calculated against diesel standard

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Phenols & Acids	.243	93.5
Others	.017	6.5

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
PHENOLS & ACIDS			
1. Phenol, 2,6-Di-tert-butyl-2,6-dimethoxy-4,4-methylenedi-	3	.002	
2. Unidentified phenol similar to Compound #1	4	.235	
3. Unidentified phenol similar to Compound #1	4	.002	
4. Unidentified phenol or acid MW 400	4	.002	
5. Unidentified Aromatic Acid MW 372	4	.002	

....2/

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
	OTHERS		
1. Phenathrene methanol-octahydro-dimethyl-(methyl ethyl)	2	.003	
2. Bromomethyl (methyl propyl) pyrimidine dione	3	.003	
3. Unidentified polycyclic, phenol or acid substituted	4	.002	
4. Unidentified Hydrocarbons	5	.009	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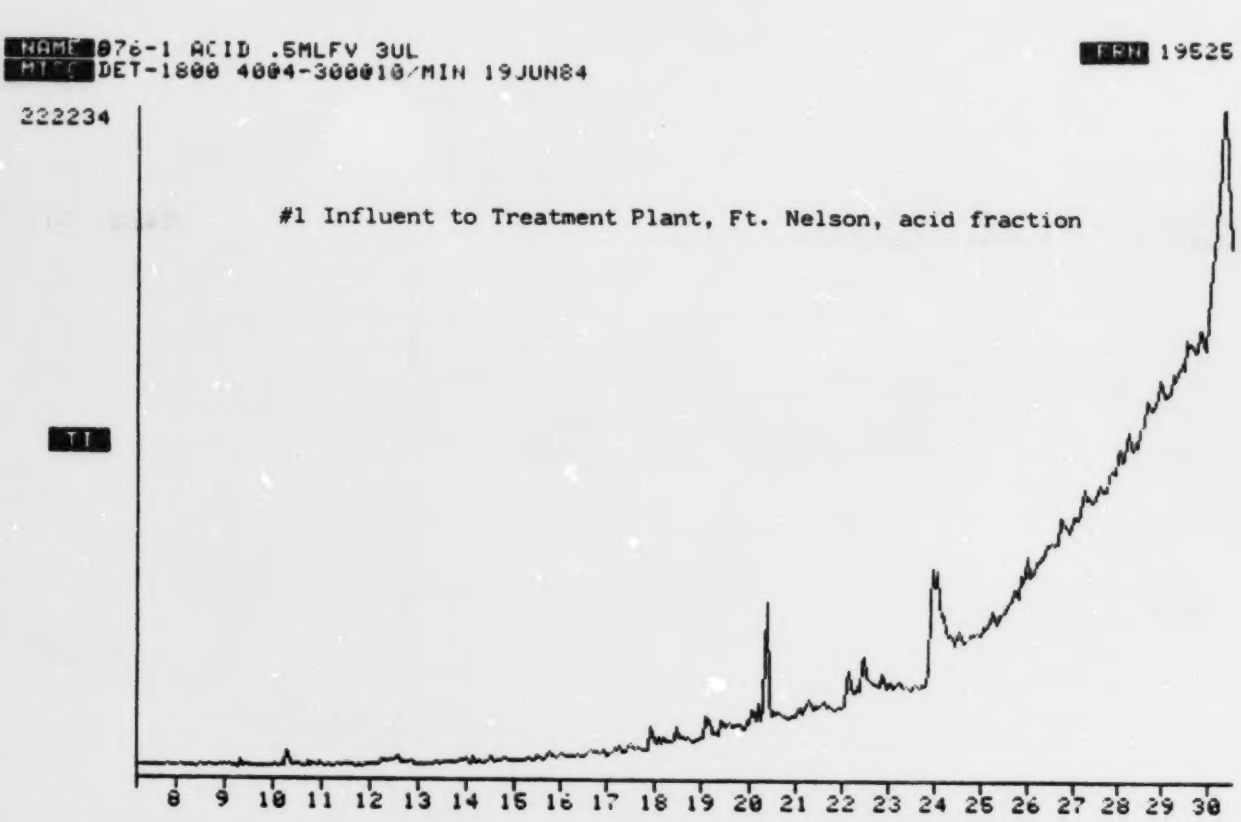
MISC DET-1800 4004-300010/MIN 18JUN84
FRN 19511
68252
#1 Influent to Treatment Plant,
Ft. Nelson, base/neutral fraction
TI
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27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MT C DET-1800 4004-300010/MIN 19JUN84
FRN 19525
222234
#1 Influent to Treatment Plant, Ft. Nelson, acid fraction
TI
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

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TABLE C-4

Analytical Results - Fort Nelson Gas Plant

Organic Analysis of Final Combined
Effluent Discharge to Nelson River
(Sample #14)

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #14 Final Combined Effluent Discharge to Nelson River

LAB SAMPLE #: 5-84-876-2, base/neutral fraction

CONCENTRATION: 0.09 ppm, total hydrocarbons, calculated against diesel, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	CONFIDENCE LEVEL	APPROXIMATE CONCENTRATION (ppm)	(%)
Alkyl Alcohol (unidentified)	4	.05	55
Unidentified Substituted Aromatic MW 212	4	.03	36
Unidentified Substituted Aromatic MW 240	4	.01	9

NOTE: Sample is very clean with only 3 major components

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #14 Final Combined Effluent Discharge to Nelson River

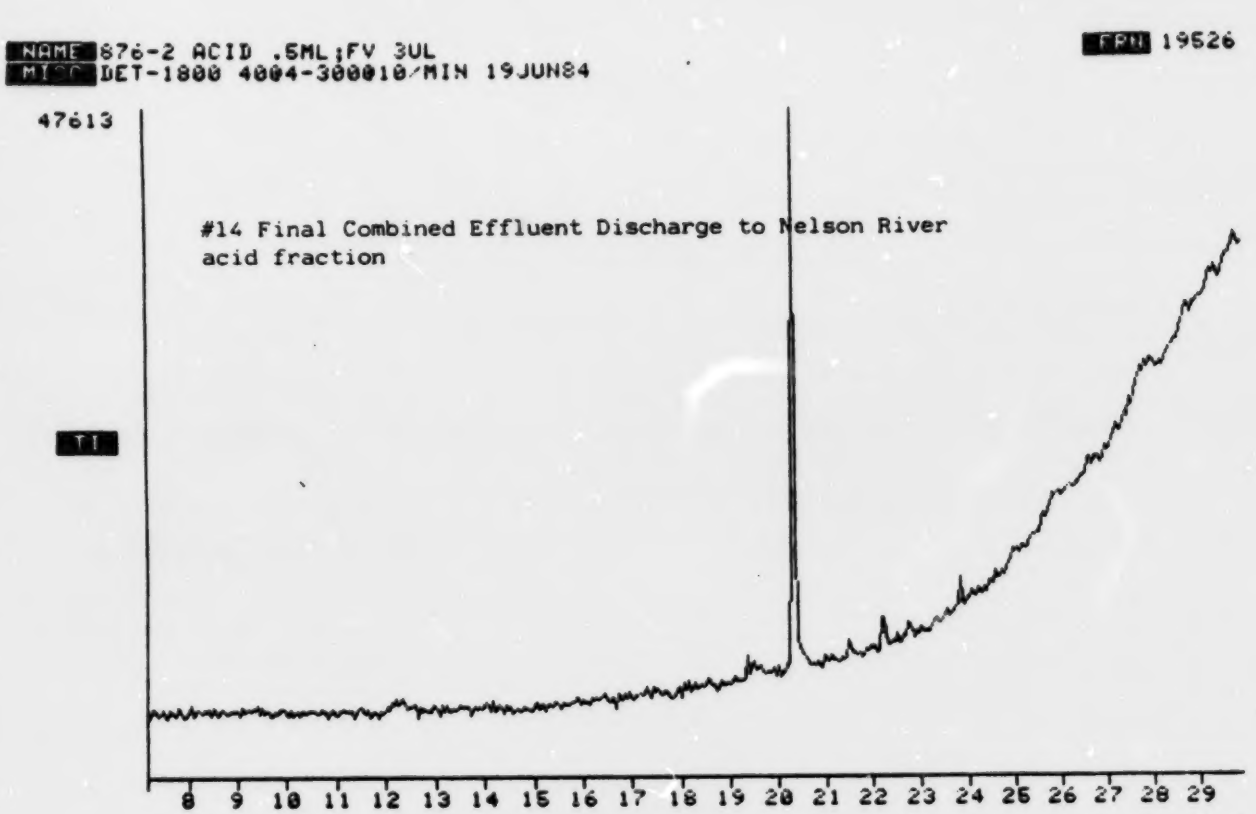
LAB SAMPLE #: 5-84-876-2 acid fraction

CONCENTRATION: .026 ppm, total hydrocarbons, calculated against diesel, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
1. Bromomethyl (methyl propyl) pyrimidinedione	3	.009	
2. Unidentified Compound	5	.016	

NOTE: Both compounds are present in the acid fraction of #1 Influent to Treatment Plant, Ft. Nelson, 5-84-876-1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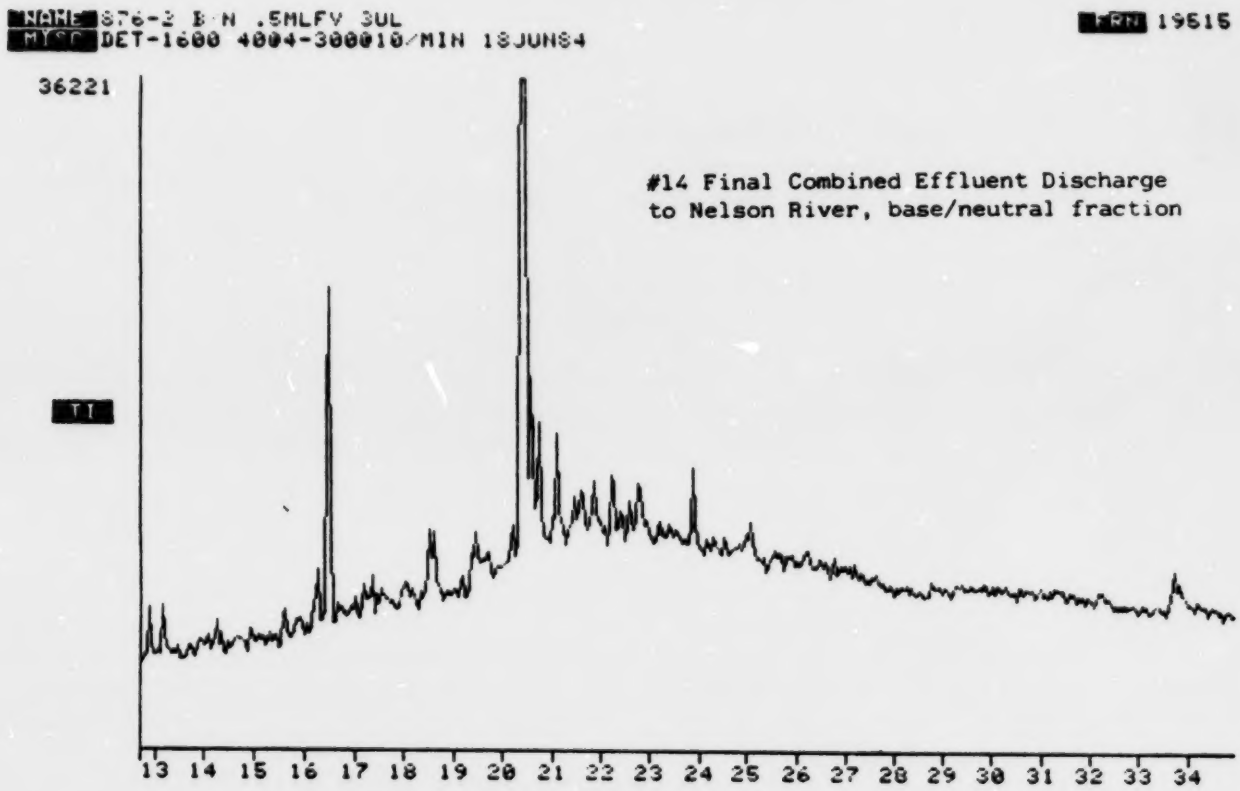
MISC DET-1800 4004-300010/MIN 19JUN84
FRN 19526
47613
#14 Final Combined Effluent Discharge to Nelson River
acid fraction
TI
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29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MISC DET-1600 4004-300010/MIN 18JUN84
RN 19515
36221
TI
#14 Final Combined Effluent Discharge
to Nelson River, base/neutral fraction
13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

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TABLE C-5

Analytical Results - Fort Nelson Gas Plant

Organic Analysis of Aeration Lagoon
Sludge (Sample #17)

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #17 Aeration Lagoon Sludge, Ft. Nelson

LAB SAMPLE #: 5-84-876-3, base/neutral fraction

CONCENTRATION: 1500 ppm (dry weight) calculated against diesel GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Paraffins	690	46
Aromatics	85	5.7
Steroids (related compounds)	534	35.6
Others (see list) Most Unidentified	184	12.3
Phthalates	10	.7

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
PARAFFINS			
1. C_{16} Branched Alkane	3	35	
2. C_{16} Hexadecane	1	52	
3. C_{18} Branched Alkane	3	55	
4. C_{17} Heptadecane	1	43	
5. C_{18} Octadecane	1	20	
6. C_{12} Dodecane	2	17	
7. C_{13} Tridecane	1	24	
8. C_{15} Branched Alkane	3	23	
9. C_{14} Tetradecane	1	50	
10. C_{16} Branched Alkane	3	66	
11. C_{15} Pentadecane	1	75	
12. Unidentified Branched Alkane	4	227	

....2/

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
AROMATICS			
1. Unidentified Aromatic	4	18	
2. Unidentified Aromatic	4	15	
3. Unidentified Aromatic MW 257	4	52	
STEROIDAL COMPOUNDS			
1. Choles-5-en-3-ol MW 386	3	107	
2. Stigmasta-7,22-dien-3-ol	3	172	
3. Other related compounds 7 compounds	4	255	
OTHERS			
1. Long Chained Alcohol MW 196	4	27	
2. Unidentified organics 8 compounds	5	157	Spectra Contaminate
PHTHALATES			
1. Bis(2-ethylhexyl)phthalate[1)]	1	10	

NOTE: Chromatogram is complex. This sample could undergo column clean-up to isolate paraffins, aromatics, PAH and heterocyclic PAH. There are many unidentified organics due to the complexity of the matrix.

1) EPA Priority Pollutant

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #17 Aeration Lagoon Sludge, Ft. Nelson

LAB SAMPLE #: 5-84-876-3, acid fraction

CONCENTRATION: 110 ppm (dry weight), calculated against diesel standard

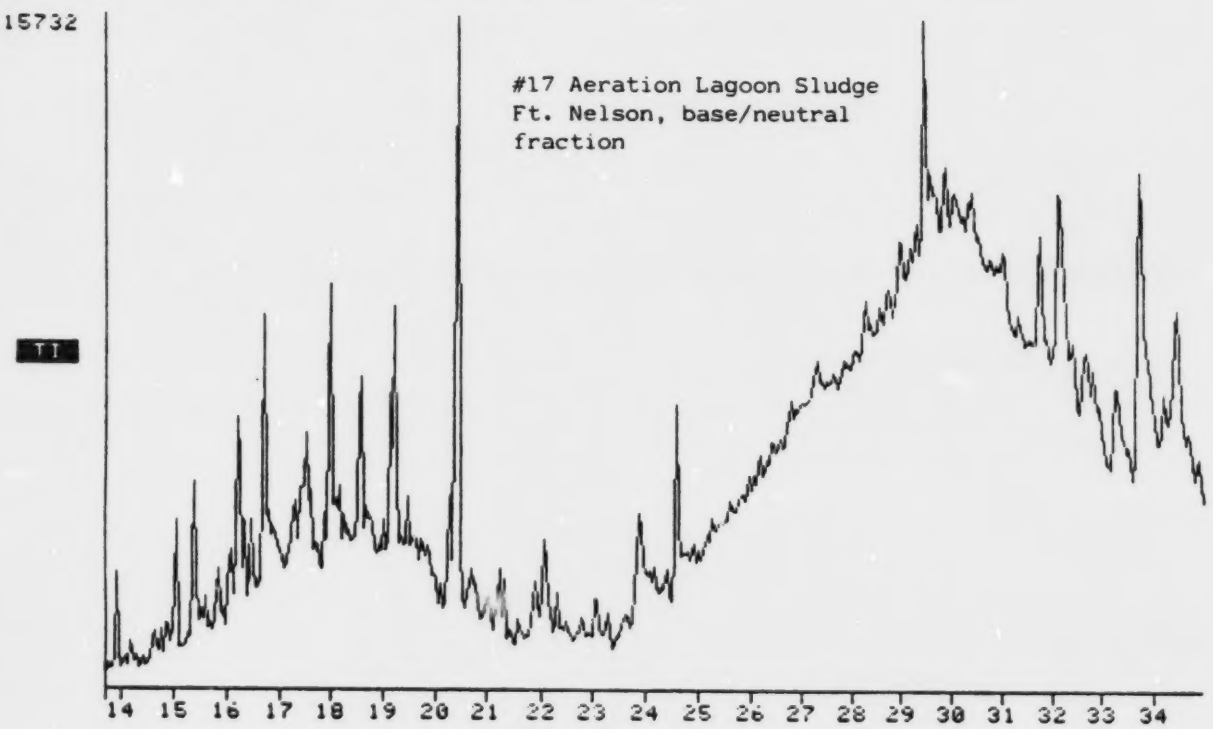
CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Acids	80	73
Alcohols	30	27

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
ACIDS			
1. Dodecanoic acid	3	2.3	
2. Tetradecanoic acid	3	1.1	
3. C_4-decanoic acid	4	2.3	
4. Pentadecanoic acid	3	27	
5. C_5-decanoic acid	3	9.2	
6. Hexadecanoic acid	3	39	
ALCOHOLS			
1. Branched Long Chained Alcohol MW 282	4	29	
2. Branched Long Chained Alcohol	4	0.6	

.....2/

NAME 876-3 B/N 10MLFV 3UL
MISC DET-1800 4004-300010/MIN 18JUN84

RRN 19513



NAME 876-3 ACID .5MLFV 3UL
MISC DET-1800 4004-300010/MIN 19JUN84
FRN 19527
292922
#17 Aeration Lagoon Sludge
Ft. Nelson, acid fraction
TI
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

C.2 PINE RIVER GAS PLANT

TABLE C-6

Analytical Results - Pine River Gas Plant
Conventional and Inorganic Pollutants in Aqueous Samples

Parameter	Concentration Units	Samples[a]						
		20	21	22	23	24	25	10
pH				6.10 ± 0.01	9.42 ± 0.01	11.50 ± 0.01	7.90 ± 0.01	7.14 ± 0.01
TSS	mg/L			2080 ± 104	63 ± 3	2.4 ± 0.2	1.6 ± 0.2	54 ± 3
Sulphide	mg/L S			17.3 ± 0.2	0.9 ± 0.2	0.4 ± 0.2	0.5 ± 0.2	0.4 ± 0.2
Sulphate	mg/L SO_4			18 ± 1	30 ± 1	213 ± 5	190 ± 5	538 ± 10
Nitrate	mg/L N			0.73 ± 0.03	0.75 ± 0.03	0.48 ± 0.02	0.06 ± 0.03	L 0.03
Ammonia	mg/L N			15 ± 1	1.5 ± 0.1	L 0.10	L 0.10	1.2 ± 0.1
TKN	mg/L N	12.2 ± 0.5		18.1 ± 0.5	282 ± 5	3.03 ± 0.05	1.09 ± 0.05	1.4 ± 0.1
TOC	mg/L C			68.2 ± 2	1200 ± 100	41 ± 2	9 ± 2	8 ± 2
COD	mg/L O_2	513000 ± 10000		1715 ± 20	6740 ± 100	143 ± 2	36 ± 1	29 ± 1
BOD	mg/L O_2						6 ± 1	
Oil and Grease	mg/L	3156 ± 10		L 0.2	L 0.2	1.6 ± 0.2	3.2 ± 0.2	L 0.2
Phenol	mg/L			0.2 ± 0.1	0.2 ± 0.1	0.6 ± 0.1	L 0.1	L 0.1
Arsenic	microg/L As	100 ± 10	L 20	L 20	L 20	L 20	L 20	L 20
Boron	mg/L B	9.23 ± 0.01	0.11 ± 0.01	1.43 ± 0.01	0.66 ± 0.01	0.08 ± 0.01	0.09 ± 0.01	0.08 ± 0.01
Barium	mg/L Ba	L[b] 0.05	L 0.05	2.0 ± 0.5	L 0.005	L 0.5	L 0.05	L 0.05
Cadmium	mg/L Cd	L 0.01	L 0.01	0.03 ± 0.01	L 0.01	L 0.01	L 0.01	L 0.01
Chromium	mg/L Cr	0.4 ± 0.1	0.063 ± 0.01	L 0.2	L 0.2	L 0.2	L 0.2	L 0.2
Copper	mg/L Cu	L 0.02	L 0.015	1.27 ± 0.02	0.05 ± 0.02	L 0.02	L 0.02	L 0.02
Cyanide	mg/L CN	19.0 ± 0.2					0.002	
Mercury	microg/L Hg	0.31 ± 0.08	L 0.08	0.14 ± 0.08	0.10 + 0.05	0.07 ± 0.05	L 0.05	0.09 ± 0.05
Manganese	mg/L Mn	4.9 ± 0.1	0.03 ± 0.01	0.11 ± 0.01	0.16 ± 0.01	0.06 ± 0.01	0.04 ± 0.01	1.51 ± 0.01
Nickel	mg/L Ni	1.2 ± 0.1	1.1 ± 0.1	L 0.1	L 0.1	L 0.1	L 0.1	L 0.1
Lead	mg/L Pb	L 0.1	L 0.1	0.2 ± 0.01	L 0.1	L 0.1	L 0.1	L 0.1
Zinc	mg/L Zn	0.14 ± 0.01	L 0.01	3.1 ± 0.1	0.46 ± 0.01	0.12 ± 0.01	0.04 ± 0.01	0.11 ± 0.01

[a] see Table 6-2 for description of sample numbers
[b] 'L' signifies less than or equal to

TABLE C-7

Analytical Results - Pine River Gas Plant
Inorganic Analysis of Sludges

Parameter	Concentration Unit	Samples[a]		
		27	28	30
pH		7.12	6.59	7.13
Oil	%	9.0 ± 0.1	5.3 ± 0.1	0.18 ± 0.01
TKN	ppm N	1200 ± 500	2240 ± 500	500 ± 50
Barium	ppm Ba	400 ± 10	362 ± 10	314 ± 10
Cadmium	ppm Cd	L2	L2	L2
Chromium	ppm Cr	8 ± 5	25 ± 5	9 ± 5
Copper	ppm Cu	13 ± 4	25 ± 4	15 ± 4
Manganese	ppm Mn	196 ± 5	98 ± 5	285 ± 10
Nickel	ppm Ni	L25	L25	L25
Lead	ppm Pb	L25	L25	115 ± 25
Zinc	ppm Zn	73 ± 3	108 ± 3	84 ± 3
Mercury	ppm Hg	0.06 ± 0.02	0.56 ± 0.04	0.06 ± 0.02
Sulphide	ppm S	180 ± 50	530 ± 150	L150
Arsenic	ppm As	L1.0	4.8 ± 0.5	5.8 ± 0.5
Boron	ppm B	60 ± 10	50 ± 10	-

[a] See Table 6-2 for description of sample numbers
[b] 'L' signifies less than or equal to

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TABLE C-8

Analytical Results - Pine River Gas Plant

Organic Analysis of Liquid from
Knockout Drum Liquid Holding Tank
(Sample #20)

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #20 Knockout Drain Liquid Holding Tank, Pine River

LAB SAMPLE #: 5-84-876-5, base/neutral fraction (water)

CONCENTRATION: 1100 ppm total hydrocarbons, calculated against diesel standard, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Paraffins	515	47
Polycyclic Aromatic Hydrocarbons	335	30
Benzothiophenes	26	2.4
Steroids (related compounds)	223	20

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
	PARAFFINS		
1. Branched Alkane C_{13}	3	4	
2. Tetradecane C_{14}	1	85	
3. Branched Alkane	3	60	
4. Pentadecane C_{15}	1	32	
5. Hexadecane C_{16}	1	44	
6. Branched Alkane C_{18}	3	21	
7. Branched Alkane C_{19}	3	72	
8. Branched Alkane C_{21}	3	4	
9. Nonadecane C_{19}	1	18	
10. Branched Alkane C_{20}	3	3	
11. Heneicosane C_{21}	1	9	
12. Docosane C_{22}	1	29	
		....2/	

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
13. Tricosane C_{23}	1	21	
14. Tetracosane C_{24}	1	10	
15. Pentacosane C_{25}	1	10	
16. Other Branched Alkanes	4	95	
POLYCYCLIC AROMATIC HYDROCARBONS			
1. Dimethylnaphthalene (isomer)	1	85	
2. Dimethylnaphthalene (isomer)	1	58	
3. Dimethylnaphthalene (isomer)	1	18	
4. Trimethylnaphthalene (isomer)	1	26	
5. Trimethylnaphthalene (isomer)	1	41	
6. Trimethylnaphthalene (isomer)	1	42	
7. Trimethylnaphthalene (isomer)	1	25	
8. C_4-Naphthalene	2	4	
9. Methylphenanthrene (isomer)	1	8	
10. Methylphenanthrene (isomer)	1	3	
11. Dimethylphenanthrene (isomer)	1	8	
12. Dimethylphenanthrene (isomer)	1	11	
13. Naphthalene [1)]	1	.3	
14. Acenaphthene [1)]	1	.3	
15. Phenanthrene [1)]	1	5	

1) EPA Priority Pollutant

.....3/

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
BENZOTHIOPHENES			
1. Methyldibenzothiophene	1	13	
2. Dimethyldibenzothiophene	2	13	
STEROIDAL TYPE COMPOUNDS			
1. Unidentified Steroid or similar compound	4	56	
2. Unidentified Steroid or similar compound	4	70	
3. Unidentified Steroid or similar compound	4	97	

NOTE: Chromatogram is complex. This sample could undergo column clean-up to isolate paraffins and in this case specifically PAH, nitrogen-PAH, sulfur-PAH etc. These compounds may be present in low concentrations.

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #20 Knockout Drain Liquid Holding Tank, Pine River

LAB SAMPLE #: 5-84-876-5, acid fraction

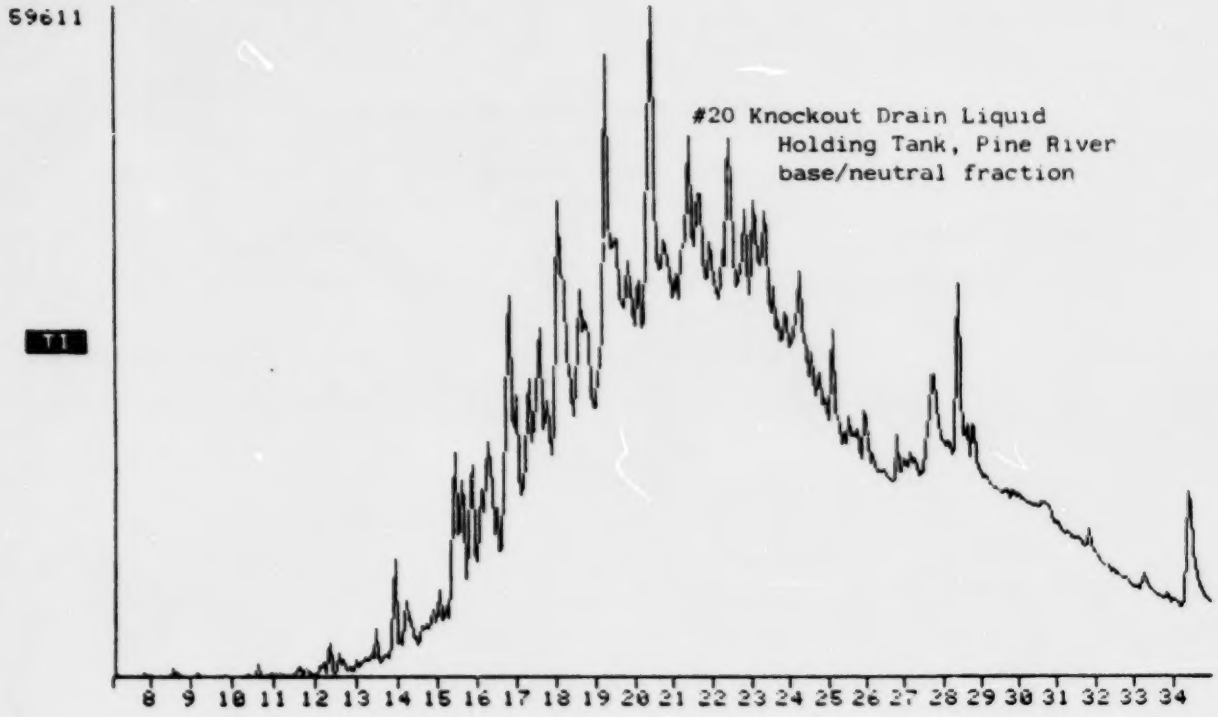
CONCENTRATION: 110 ppm, total hydrocarbons, calculated against diesel standard GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Acids	80	73
Others	30	27

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
ACIDS			
1. Unidentified Acid or Acid ester MW 120	4	3	
2. Unidentified Acid or Acid ester MW 142	4	70	
3. Unidentified Acid or Acid ester MW 116	4	7	
OTHERS			
1. Pentathiepane	3	10	
2. Phenanthrene carboxylic acid -octahydro-dimethyl-(methylethyl)	3	20	

NAME 876-5 B/N 100MLFV 3UL
MISC DET-1600 4004-300010/MIN 19JUN84

PAGE 19519


59611
TI
#20 Knockout Drain Liquid
Holding Tank, Pine River
base/neutral fraction
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

NAME 876-5 10MLFV 3UL
MISC DET-1800 4004-300010 MIN 19JUN84

FRN 19629

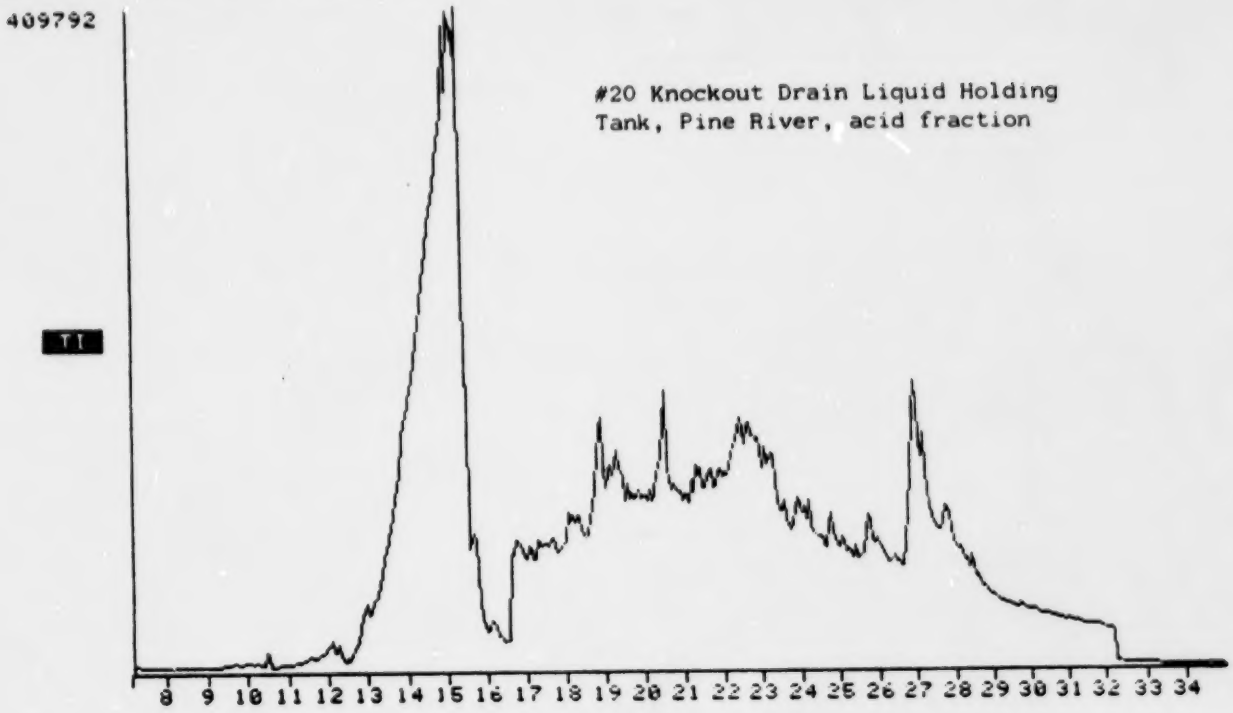


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TABLE C-9

Analytical Results - Pine River Gas Plant

Organic Analysis of Combined Effluent for Spray Irrigation (Sample #25)

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #25 Combined Effluent for Spray Irrigation, Pine River, Water Sample

LAB SAMPLE #: 5-84-876-6 base/neutral fraction

CONCENTRATION: 0.38 ppm total hydrocarbons, calculated against diesel, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	CONFIDENCE LEVEL	APPROXIMATE CONCENTRATION (ppm)	(%)
Substituted Morpholine or Cyclic Nitrogen compound	4	0.38	100

NOTE: Sample is very clean with only one major component present.

The compound identified has been found in other gas plant effluent samples and in ground water samples taken in and around gas plants.

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS

SUMMARY OF IDENTIFICATION BY GC/MS

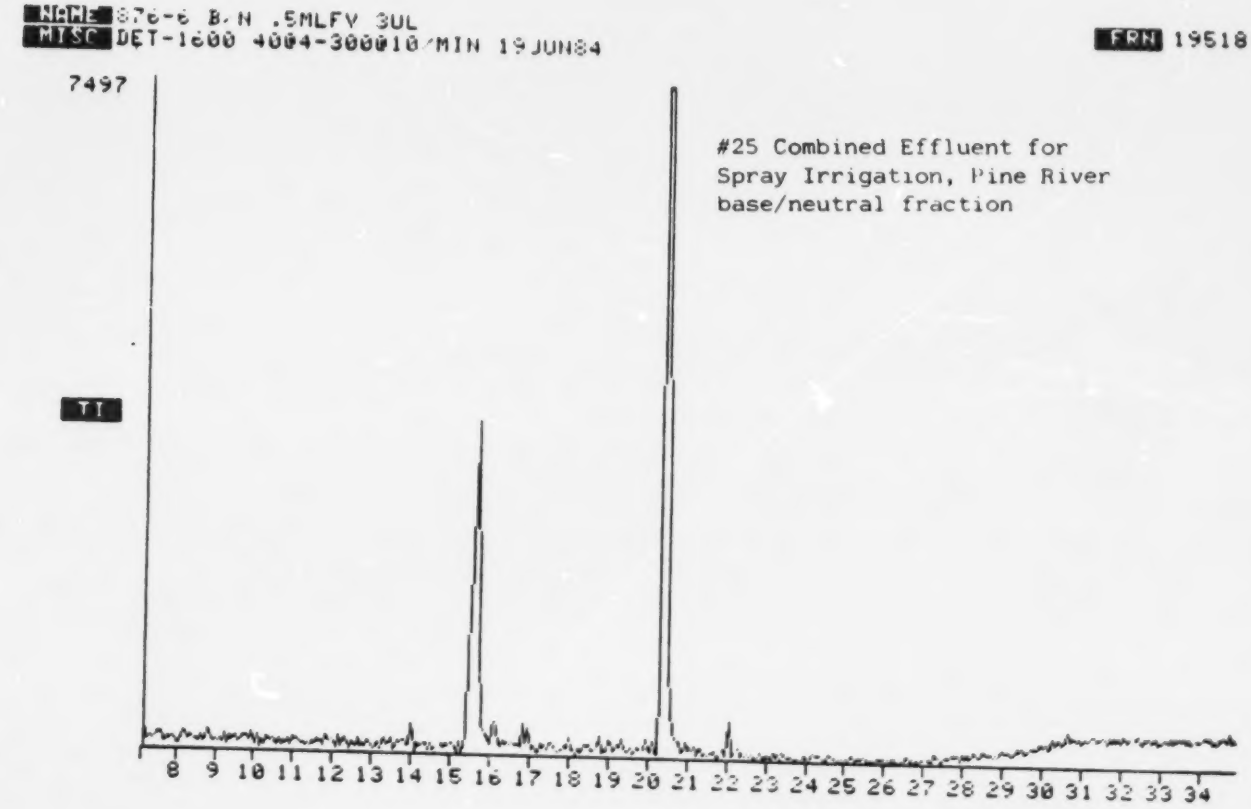
SAMPLE: #25 Combined Effluent for Spray Irrigation, Pine River

LAB SAMPLE #: 5-84-876-6, acid fraction

CONCENTRATION: 0.14 ppm total hydrocarbons, calculated against diesel, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Substituted Morpholine or Cyclic Nitrogen compound	0.14	100

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS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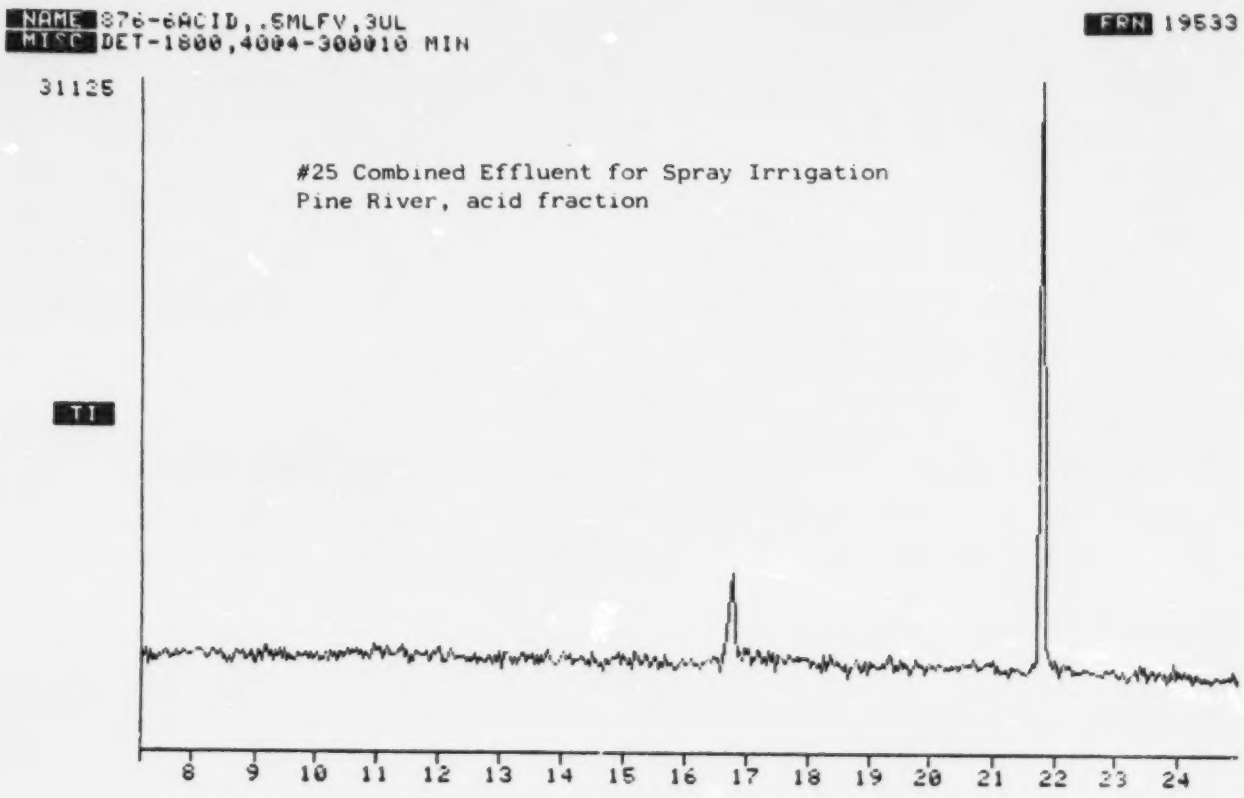
MISC DET-1600 4004-300010/MIN 19JUN84
FRN 19518
7497
TI
#25 Combined Effluent for
Spray Irrigation, Pine River
base/neutral fraction
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34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MISC DET-1800,4004-300010 MIN
FRN 19533
31135
#25 Combined Effluent for Spray Irrigation
Pine River, acid fraction
TI
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

C.3 TAYLOR GAS PLANT

TABLE C-10

Analytical Results - Taylor Gas Plant
Conventional and Inorganic Pollutants in Aqueous Samples

Parameter	Concentration Units	Samples[a]			
		34	36	37	38
pH		12.43 ± 0.01	8.25 ± 0.01	9.48 ± 0.01	6.88 ± 0.01
TSS	mg/L	65 ± 3	1.2 ± 0.2	102 ± 5	188 ± 9
Sulphide	mg/L S	13.6 ± 0.2	292 ± 1	40.0 ± 0.4	1.5 ± 0.2
Sulphate	mg/L SO_4	101 ± 3	188 ± 2	37 ± 1	838 ± 15
Nitrate	mg/L N	L[b]0.03	L0.03	L0.03	0.13 ± 0.03
Ammonia	mg/L N	15 ± 1	204 ± 10	3.9 ± 0.1	L0.10
TKN	mg/L N	670 ± 10	230 ± 2	22.9 ± 0.5	2.35 ± 0.05
TOC	mg/L C	700 ± 100	65 ± 10	51 ± 2	19 ± 2
COD	mg/L O_2	3050 ± 50	598 ± 10	232 ± 5	107 ± 2
Oil and Grease	mg/L	6.6 ± 0.2	6.2 ± 0.2	4.2 ± 0.2	L0.2
Phenol	mg/L	L0.1	L0.1	10.4 ± 0.5	L0.1
Arsenic	microg/L As	L20	L20	L20	L20
Boron	mg/L B	0.08 ± 0.01	0.07 ± 0.01	0.27 ± 0.01	0.05 ± 0.01
Barium	mg/L Ba	L0.5	L0.5	L0.5	L0.5
Cadmium	mg/L Cd	L0.01	L0.01	L0.01	L0.01
Chromium	mg/L Cr	L0.2	L0.2	L0.2	L0.2
Copper	mg/L Cu	0.03 ± 0.02	L0.02	L0.02	L0.02
Mercury	microg/L Hg	0.21 ± 0.05	L0.05	0.11 ± 0.05	L0.05
Manganese	mg/L Mn	L0.01	0.03 ± 0.01	0.10 ± 0.01	0.39 ± 0.1
Nickel	mg/L Ni	L0.1	L0.1	L0.1	L0.1
Lead	mg/L Pb	L0.1	L0.1	L0.1	L0.1
Zinc	mg/L Zn	0.20 ± 0.01	0.06 ± 0.01	0.08 ± 0.01	0.13 ± 0.01

[a] See Table 6-3 for description of sample numbers
[b] 'L' signifies less than or equal to

TABLE O-11

Analytical Results - Taylor Gas Plant
Inorganic Analysis of Sludges

Parameter	Concentration Unit	Samples[a]	
		40	42
pH		6.91	7.15
Oil	%	10.1 ± 0.1	4.3 ± 0.1
TKN	ppm N	63500 ± 7000	5230 ± 500
Barium	ppm Ba	850 ± 100	288 ± 10
Cadmium	ppm Cd	23 ± 2	L2
Chromium	ppm Cr	62 ± 5	31 ± 5
Copper	ppm Cu	115 ± 4	109 ± 4
Manganese	ppm Mn	132 ± 5	380 ± 10
Nickel	ppm Ni	35 ± 25	55 ± 25
Lead	ppm Pb	119 ± 25	L25
Zinc	ppm Zn	465 ± 25	188 ± 25
Mercury	ppm Hg	1.81 ± 0.12	0.22 ± 0.02
Sulphide	ppm S	L[b]600	950 ± 150
Arsenic	ppm As	6.5 ± 0.5	28.2 ± 2.5
Boron	ppm B	50 ± 10	-

[a] See Table 6-3 for description of sample numbers
[b] 'L' signifies less than or equal to

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TABLE C-12

Analytical Results - Taylor Gas Plant

Organic Analysis of Fluid from the
Gas Treating Open Drain (Sample #34)

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #34 Gas Treating Open Drain Taylor, Water Sample

LAB SAMPLE #: 5-84-876-4, base/neutral fraction

CONCENTRATION: 1.5 ppm, total hydrocarbons, calculated against diesel, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Paraffins	.82	55
Phenols	.57	38
PAH	.017	1.1
Others (see list)	.094	6.3

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
	PARAFFINS		
1. Pentadecane C_{15}	1	.012	
2. Hexadecane C_{16}	1	.012	
3. Heptadecane C_{17}	1	.012	
4. Heneicosane C_{21}	1	.033	
5. Docosane C_{22}	1	.025	
6. Tetracosane C_{24}	1	.034	
7. Pentacosane C_{25}	1	.042	
8. Hexacosane C_{26}	1	.034	
9. Nonadecane C_{19}	1	.028	
10. Eicosane C_{20}	1	.077	
11. Heptacosane C_{27}	1	.035	
12. Octacosane C_{28}	1	.035	

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COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
13. Nonacosane C_{29}	1	.035	
14. Tricontane C_{30}	1	.040	
15. Hentriacontane C_{31}	1	.030	
16. Doctriacontane C_{32}	1	.035	
17. Tritriacontane C_{33}	1	.030	
18. Other Branched Alkanes	4	.270	
PHENOLS			
1. Nonyl phenol MW 220	1	.063	Compounds similar to these have been found in other gas plant evaporation ponds
2. C_9 Substituted Phenols 6 compounds, MW 220	4	.129	
3. 2,4-Bis(1-methylbutyl)phenol	3	.009	
4. C_{12} Substituted Phenols 5 compounds, MW 264	4	.200	
5. C_{15} Substituted Phenols 4 compounds MW 308	4	.166	
POLYCYCLIC AROMATIC HYDROCARBONS			
1. Methyl phenanthrene	2	.005	
2. Naphthalene [1)]	1	.005	
3. Phenanthrene [1)]	1	.007	

1) EPA Priority Pollutants

.....3/

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
	OTHERS		
1. N,N-dimethyl cyclohexanamine	1	.012	
2. Ethyl hexanol	3	.012	
3. Benzene diamine or C_9-phenol MW 220	4	.022	
4. Unidentified aliphatic nitrile MW 250	4	.033	
5. Methyl dibenzothiophene	2	.02	
6. Unidentified aromatic nitrogen	4	.013	

NOTE: Chromatogram (GC/MS) see attached, is extremely complex. The sample could undergo column clean-up to isolate paraffin, aromatic and sub fractions of the aromatics which may result in the isolation of low level PAH compounds and heterocyclics of PAH's.

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: #34 Gas Treating Open Drain Taylor , Water Sample

LAB SAMPLE #: 5-84-876-4, acid fraction

CONCENTRATION: 1.1 ppm total hydrocarbons, calculated against diesel, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Paraffins	.460	42
Phenols	.380	35
Others	.260	23

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
	PARAFFINS		
1. Hexadecane C_{16}	1	.008	
2. Heptadecane C_{17}	1	.012	
3. Octodecane C_{18}	1	.024	
4. Nonadecane C_{19}	1	.118	
5. Eicosane C_{20}	1	.044	
6. Docosane C_{22}	1	.025	
7. Tetracosane C_{24}	1	.025	
8. Pentacosane C_{25}	1	.035	
9. Hexacosane C_{26}	1	.014	
10. Octacosane C_{28}	1	.015	
11. Nonacosane C_{29}	1	.015	
12. Triacontane C_{30}	1	.015	

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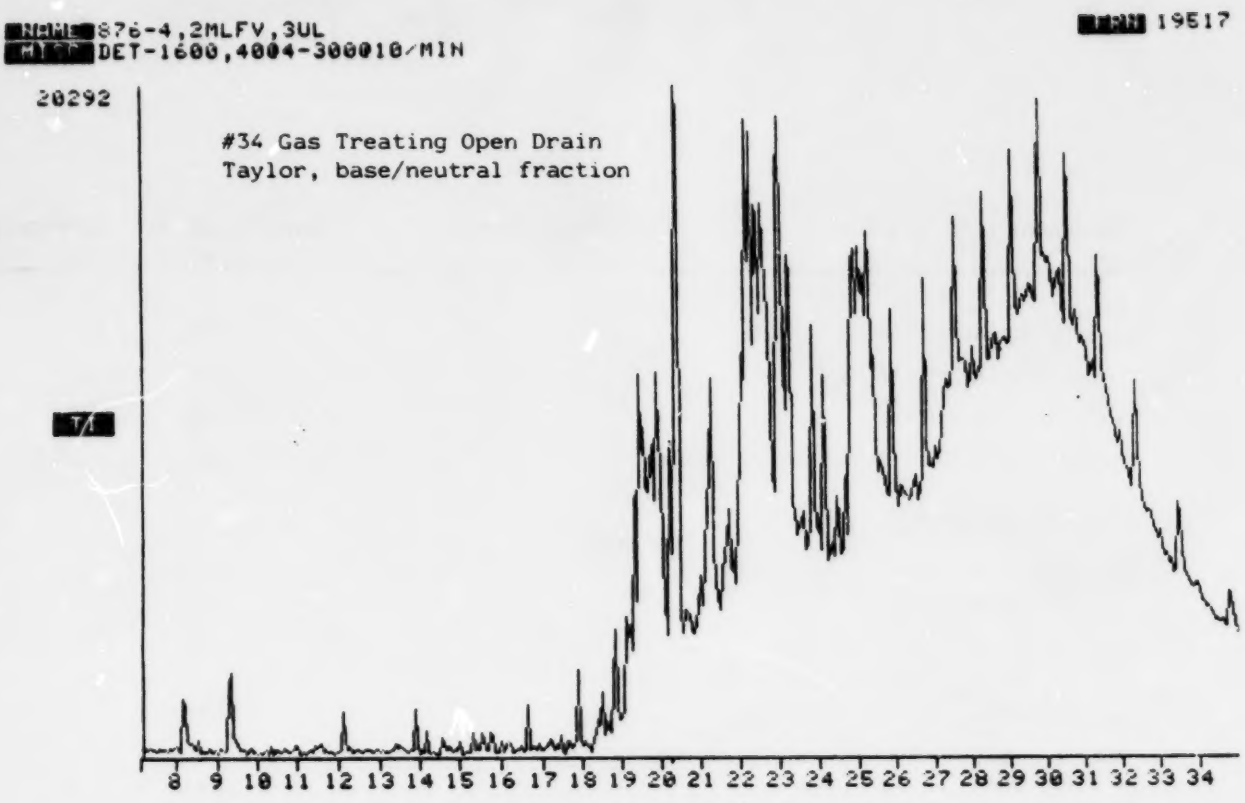
COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
13. Hentriacontane C_{31}	1	.015	
14. Doctriacontane C_{32}	1	.035	
15. Tritriacontane C_{33}	1	.035	
16. Unidentified Branched Alkanes	4	.021	
PHENOLS			
1. Nonyl phenol	1	.012	
2. C_9-Substituted phenols MW 120	4	.008	
3. C_{12}-Substituted phenols MW 264 5 compounds	4	.052	
4. C_{15}-Substituted phenols MW 308 4 compounds	4	.275	
5. Unidentified phenols	5	.035	
OTHERS			
1. Methyl phenanthrene	1	.004	
2. Unidentified Aromatic	4	.025	
3. Long Chained Alcohol MW 224	4	85	
4. Long Chained Alcohol	4	44	
5. Unidentified Hydrocarbons	5	.104	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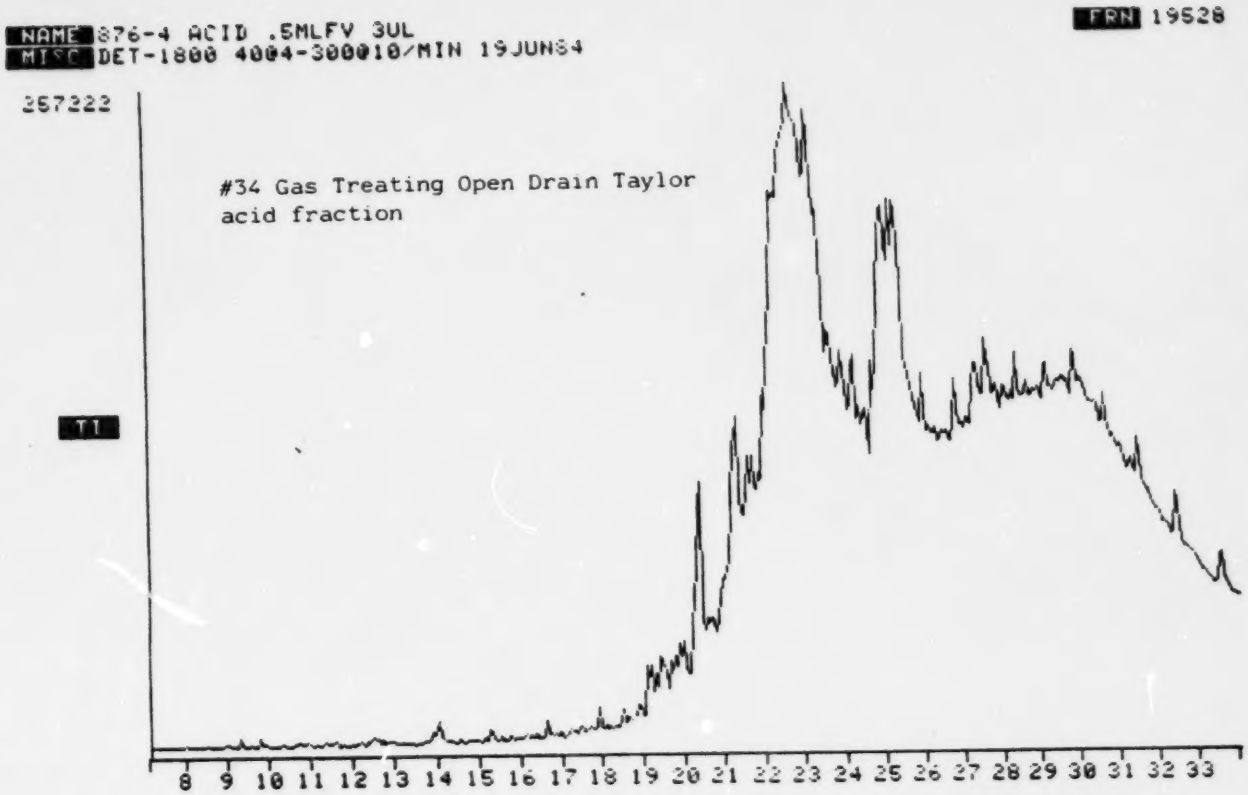
DET-1600,4004-300010/MIN
19517
20292
#34 Gas Treating Open Drain
Taylor, base/neutral fraction
T/
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34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FRN 19528
257222
#34 Gas Treating Open Drain Taylor
acid fraction
TI
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

C.4 KITIMAT METHANOL PLANT

TABLE C-13

Analytical Results - Kitimat Methanol Plant
Conventional and Inorganic Pollutants in Aqueous Samples

Parameter	Concentration Units	Samples[a]		
		43	44	45
pH		7.03 ± 0.01	10.24 ± 0.01	7.21 ± 0.01
TDS	mg/L	276 ± 5	86 ± 2	614 ± 12
TSS	mg/L	71.5 ± 3.5	1.0 ± 0.5	34.5 ± 1.7
Sulphate	mg/L SO_4	12.5 ± 0.5	L2	290 ± 5
Sulphide	mg/L S	L[b]0.2	L0.2	0.8 ± 0.2
Nitrate	mg/L N	0.36 ± 0.05	L0.05	0.18 ± 0.05
Ammonia	mg/L N	L0.10	L0.10	1.1 ± 0.1
TKN	mg/L N	0.27 ± 0.15	0.27 ± 0.15	1.50 ± 0.15
TOC	mg/L C	23 ± 3	41 ± 3	11 ± 3
COD	mg/L O_2	79 ± 2	122 ± 2	44 ± 1
Oil and Grease	mg/L	3 ± 1	L1	L1
Phenol	mg/L	0.2 ± 0.1	L0.1	L0.1
Arsenic	microg/L As	L10	L10	L10
Boron	mg/L B	0.6 ± 0.2	1.8 ± 0.2	1.8 ± 0.2
Barium	mg/L Ba	L0.1	L0.1	L0.1
Cadmium	mg/L Cd	L0.01	L0.01	L0.01
Chromium	mg/L Cr	0.08 ± 0.02	L0.04	L0.04
Copper	mg/L Cu	0.05 ± 0.01	L0.02	L0.02
Mercury	microg/L Hg	0.21 ± 0.05	L0.08	0.83 ± 0.08
Manganese	mg/L Mn	0.060 ± 0.005	L0.01	0.040 ± 0.005
Nickel	mg/L Ni	0.05 ± 0.02	0.06 ± 0.02	L0.04
Lead	mg/L Pb	0.06 ± 0.02	L0.04	L0.04
Zinc	ppm Zn	L0.02	L0.02	L0.02

[a] See Table 6-4 for description of sample numbers
[b] 'L' signifies less than or equal to

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TABLE C-14

Analytical Results - Kitimat Gas Plant

Organic Analysis of Process Water

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: Kitimat Methanol Plant, Process Water

LAB SAMPLE #: 4-84-741-1, base/neutral fraction (water)

CONCENTRATION: 7.2 ppm total extractable hydrocarbons, calculated against diesel standard, GC/FID

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Paraffins		100

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
	PARAFFINS		
1. Tetradecane C_{14}	1	.055	
2. Pentadecane C_{15}	1	.215	
3. Hexadecane C_{16}	1	.395	
4. Heptadecane C_{17}	1	.514	
5. Octadecane C_{18}	1	.480	
6. Nonadecane C_{19}	1	.453	
7. Eicosane C_{20}	1	.440	
8. Heneicosane C_{21}	1	.440	
9. Docosane C_{22}	1	.475	
10. Tricosane C_{23}	1	.470	
11. Tetracosane C_{24}	1	.470	
12. Pentacosane C_{25}	1	.470	

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COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
13. Hexacosane C_{26}	1	.445	
14. Heptacosane C_{27}	1	.374	
15. Branched Alkanes	4	1.500	
POLYCYCLIC AROMATIC HYDROCARBONS			
1. Naphthalene[1)]	1	Trace (less than 1 ppb)	

NOTE: Chromatogram is complex (see attached). This sample could undergo column clean-up to isolate paraffins and aromatics (eg. PAH). Other PAH compounds may be present at low levels.

1) EPA Priority Pollutant

SUMMARY OF IDENTIFICATION BY GC/MS

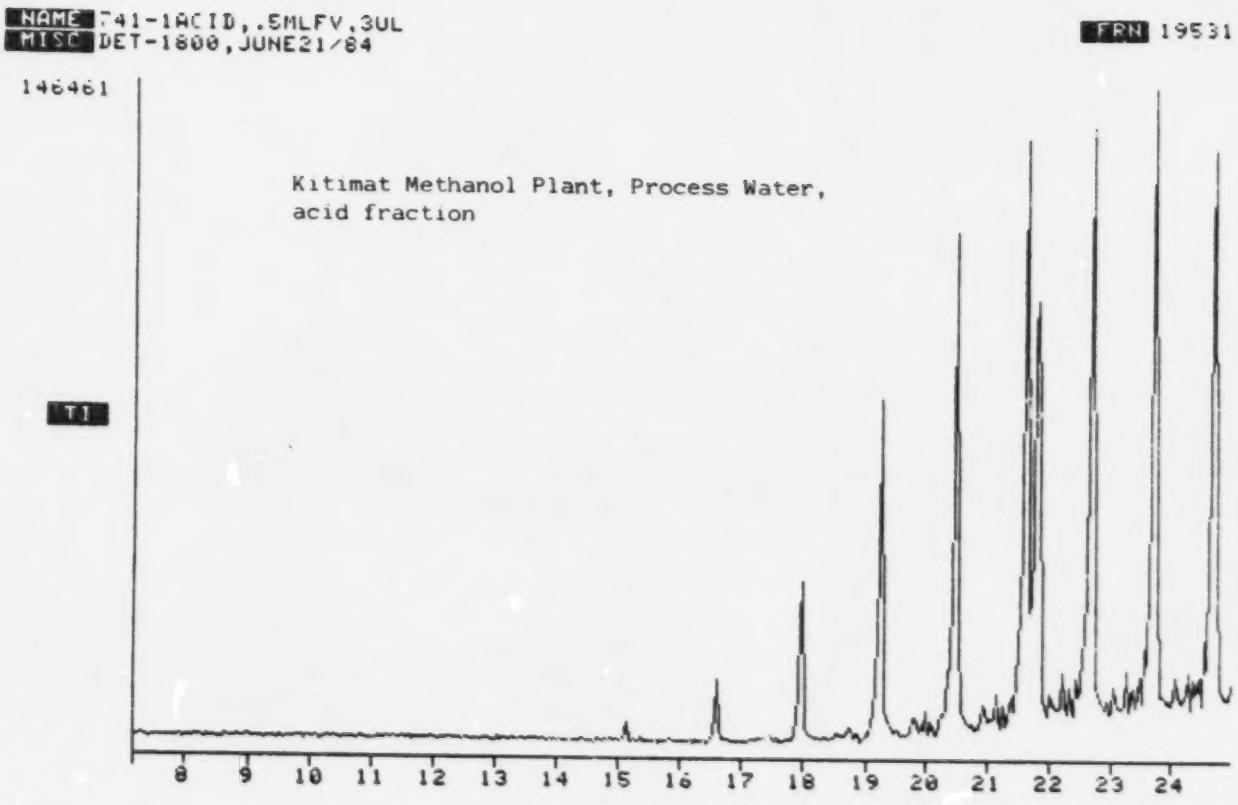
SAMPLE: Kitimat Methanol Plant, Process Water

LAB SAMPLE #: 4-84-741-1, acid fraction

CONCENTRATION: 2.7 ppm total extractable hydrocarbons, calculated against diesel standard

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
Paraffins	2.7	100

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS
	PARAFFINS		
C_{14} to C_{25} straight chained Alkanes and additional Branched Alkanes	1	2.7	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MISC DET-1800,JUNE21/84
FRN 19531
146461
Kitimat Methanol Plant, Process Water,
acid fraction
TI
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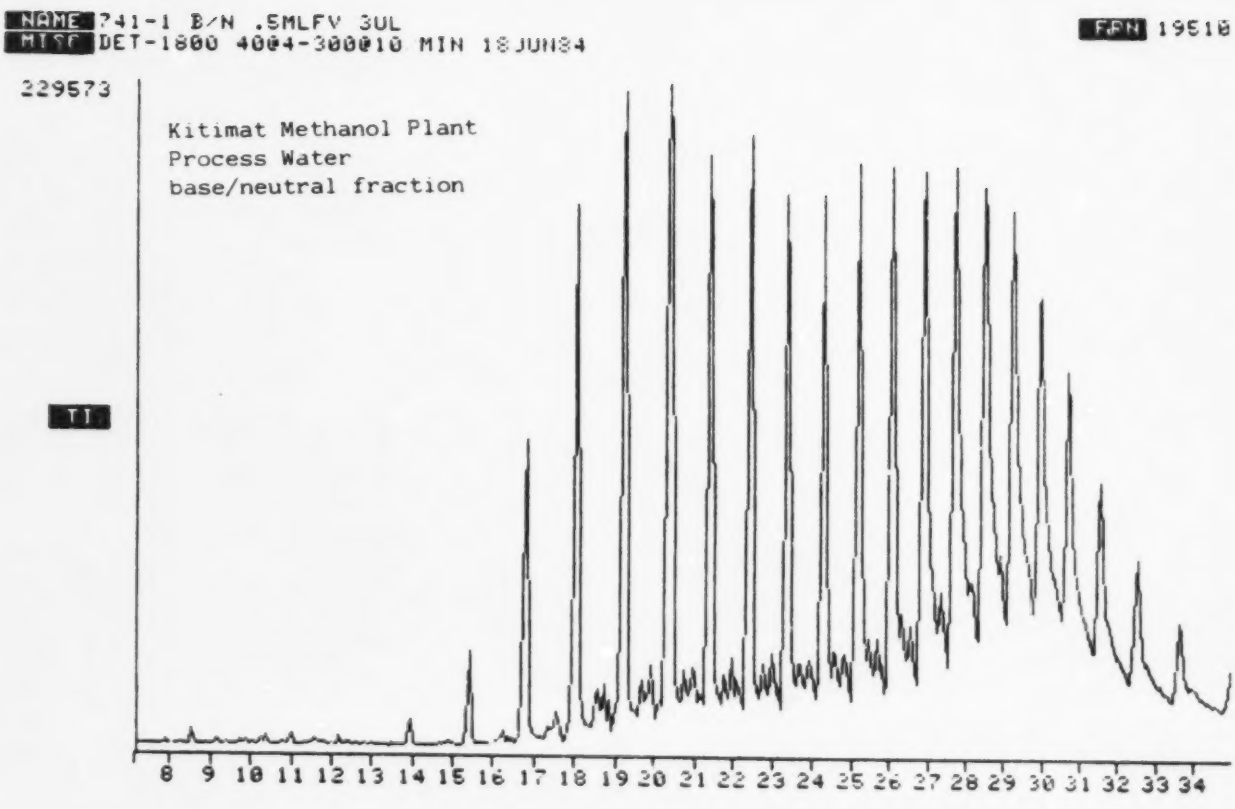
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FRN 19518
229573
Kitimat Methanol Plant
Process Water
base/neutral fraction
TI
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

C.5 BACKGROUND ON GC/MS ANALYSIS

Analysis of
6 Water & 1 Sludge
for
Characterization by
Gas Chromatography / Mass Spectrometry
EPA Target Compound
&
Non-Target Compound Scan

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A Division of ETL Chemspec Analytical Limited

9936 - 67th Avenue — Edmonton, Alberta T6E 0P5
Telephone: (403) 434-9509

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9936 - 67th Avenue – Edmonton, Alberta T6E 0P5 Telephone: (403) 434-9509

Analysis of
6 Water & 1 Sludge
for
Characterization by
Gas Chromatography / Mass Spectrometry
EPA Target Compound
&
Non-Target Compound Scan

Submitted
to
Monenco Consultants Ltd.
July 12, 1984

Certified By.....

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1. LIST OF SAMPLES SUBMITTED

SAMPLE IDENTIFIER	LAB SAMPLE#
1) Kitimat Methanol Plant, Process Water	4-84-741-1
2) #1 Influent to Treatment Plant, Ft. Nelson (Water)	5-84-876-1
3) #14 Final Combined Effluent Discharge to Nelson River (Water)	5-84-876-2
4) #17 Aeration Lagoon Sludge, Ft. Nelson	5-84-876-3
5) #34 Gas Treating Open Drain Taylor (Water)	5-84-876-4
6) #20 Knockout Drain Liquid Holding Tank, Pine River (Water)	5-84-876-5
7) #25 Combined Effluent for Spray Irrigation, Pine River (Water)	5-84-876-6

2. EXTRACTION PROCEDURES

1) Water Samples

The water samples are extracted according to method 625 (EPA). The sample 2L is transferred to a seperatory funnel and extracted under basic conditions (pH 11-12, 6N NaOH) with 3X100 mls of methylene chloride. The organic extracts are combined and dried over sodium sulfate. This base/neutral fraction is then reduced to 1 to 2 ml using rotovap for concentration. The sample is quantitatively transferred to a 3 & 1/2 ml vial and reduced to a known volume using a gentle stream of nitrogen. The aqueous is make acidic (pH 1-2, 6N HCl) and extracted serially with 3X100 mls of methylene chloride thus resulting in an acid fraction. This fraction is dried and concentrated in the same fashion as the base/neutral fraction.

2) Sludge Samples

The sludge sample is shaken in acidic acetonitrile (pH 1-2, 6N HCl) 200 mls for 8 hours on a mechanical shaker. The sample is filtered and transferred to a seperatory funnel. 300 mls of distilled water is added

.....2/

to the sample and the sample is made basic (pH 11-12, 6N NaOH) and extracted serially with 15% ether in hexane (3X60). The organic extracts are combined, dried over sodium sulfate and reduced to 1 to 2 ml using rotovap for concentration. The sample was then made up in exactly 10 mls. Further dilutions were made when required.

3. TECHNIQUES USED IN GC/MS ANALYSIS

Two techniques are used to identify individual organic compounds.

1) EPA Target Compound Analysis

This method uses extracted ion techniques and is very selective and sensitive. The analysis is automated by the use of a sophisticated GC/MS software program which searches, extracts, identifies and quantitates the target EPA organics. Quantitations of the EPA target compounds is not semi-quantitative as is the case for the nor-target work. Every compound analyzed is run against a known calibration standard using the internal standard anthracene - D_{10}.

2) Non-Target Identifications of Organics Using GC/MS - NBS Library Search Techniques and Manual Interpretation

This is a semi-automated method which is potentially capable of identifying every organic compound which has been resolved (high resolution capillary column) and which is present at concentrations detectable by mass spectrometry. This is a total ion technique and lacks the sensitivity achieved using the target compound selective ion technique. The final interpretation is done by the analyst who makes decisions regarding the accuracy of the library match (see table of confidence of identification of GC/MS spectra, Page 4). Quantitation using this method is semi-quantitative only.

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4. GC/FID FOR FINGERPRINTING AND SEMI-QUANTITATION

Initial fingerprinting and semi-quantitation are achieved using GC/FID. Diesel oil is used as external standard to calculate a semi-quantitative total hydrocarbon content. Individual organics identified in the non-target GC/MS analysis are quantitated using a combination of percentage amount calculated by a specific GC/MS software program combined with the result obtained from the GC/FID analysis.

5. LIST OF EPA PRIORITY POLLUTANTS ANALYZED

(see next page) Detection limits apply for all of the water extraction.

6. DETECTION LIMITS (APPROXIMATE)

a. Detection limit for EPA priority pollutants selected ion scan: - solids & sludges - .1 to .5 ppm

b. Detection limit for general non-target organics:
- solids & sludges - 1 to 2 ppm

c. Water - see next page

7. QUALITY CONTROL

Blanks: Method blanks are analyzed along with the samples. Compounds present in the method blanks are subtracted when detected in actual samples.

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EPA Priority Pollutant List
Compound Analysed By GC/MS, EPA Method 625

Base/Neutral	Detection Limit ppb, (ug/L)
Benzidine	5
Bis(2-chloroethyoxy)methane	5
Bis(2-chloroethyl)ether	5
Bis(2-chloroisopropyl)ether	5
Bis(2-ethylhexyl)phthalate	3
4-Bromophenyl phenyl ether	3
Butyl benzyl phthalate	3
2-Chloronaphthalene	3
4-Chlorophenyl phenyl ether	5
1,2-Dichlorobenzene	5
1,3-Dichlorobenzene	5
1,4-Dichlorobenzene	5
3,3'-Dichlorobenzidine	5
Dimethylphthalate	3
Diethylphthalate	3
Di-n-butylphthalate	3
2,4-Dinitrotoluene	3
2,6-Dinitrotoluene	3
1,2-Diphenylhydrazine	NR
Hexachlorobenzene	3
Hexachlorobutadiene	3
Hexachlorocyclopentadiene	3
Isophorone	3
Nitrobenzene	3
N-Nitrosodiphenylamine	10
N-Nitrosodimethylamine	10
N-Nitrosodi-n-propylamine	10
1,2,4-Trichlorobenzene	3

Phenols	Detection Limit ppb, (ug/L)
2-Chlorophenol	3
2,4-Dichlorophenol	3
2,4-Dimethylphenol	3
4,6-Dinitro-o-cresol	20
2,4-Dinitrophenol	20
2-Nitrophenol	20
4-Nitrophenol	20
P-Chloro-m-cresol	3
Pentachlorophenol	20
Phenol	3
2,4,6-Trichlorophenol	3

Polycyclic Aromatics	Detection Limit ppb, (ug/L)
Acenaphthene	3
Acenaphthylene	3
Anthracene	3
Benzo(a)anthracene or Chrysene	5
Benzo(k)fluoranthene or Benzo(b)fluoranthene	5
Benzo(a)pyrene	10
Fluoranthene	3
Fluorene	3
Naphthalene	3
Phenanthrene	3
Pyrene	3

Pesticides	Detection Limit ppb, (ug/L)
Aldrin	3
Alpha-BHC	3
Beta-BHC	3
Gamma-BHC	3
Delta-BHC	3
Chlordane	NR
4,4'-DDT	5
4,4'-DDE	5
4,4'-DDD	5
Dieldrin	3
Alpha-Endosulfan	3
Beta-Endosulfan	3
Endrin	3
Heptachlor	3
Heptachlor Epoxide	NR
PCB-1242	30
PCB-1254	30
PCB-1221	30
PCB-1232	30
PCB-1248	30
PCB-1260	30
PCB-1016	30

* Approximate detection limits are reported for aqueous samples.
* Detection limits for soils & sediments would be greater by an approximate factor of 10.
* NR - Not run at present.

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8. COMMENTS

a. Oil and Grease test compared to total extractables detected by GC/FID:

Oil and grease is a gravametric test (weight) which results in the measurement of the total extractable hydrocarbons. The GC/FID semi-quantitative analysis measures only those hydrocarbons which are resolved by a chromatographic column. The two tests may not correlate exactly and in most cases the oil and grease test will result in a higher result.

b. Raw Mass Spectra are available upon request.

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GC/MS DETAILED RESULTS

1. EXPLANATION OF RESULTS

Each sample processed for GC/MS analysis is presented as follows:

a. Summary of identifications

b. List of groups of compounds and specific compounds identified.

c. Chromatogram of compounds detected by GC/MS.

2. TABLE OF CONFIDENCE OF IDENTIFICATION OF GC/MS SPECTRA

Number 1: Very confident, clean spectra, excellent match with library spectra.

Number 2: Some small spectra differences with library match. A good comparison. Reference standard needed for positive identification.

Number 3: Possible compound or very similar to. Spectra is difinitely contaminated. Reference standard needed for positive identification.

Number 4: Evidence of possible structure and molecular weight. Compound not identified.

Number 5: Unable to identify.

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SAMPLE

876-Blank

5-84-876-blank

SUMMARY OF IDENTIFICATION BY GC/MS

SAMPLE: 876-Blank

LAB SAMPLE #: 5-84-876-blank, base/neutral fraction

CONCENTRATION: 0.040 ppm total extractable hydrocarbons, calculated against diesel

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)

See chromatogram

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS

SUMMARY Of IDENTIFICATION BY GC/MS

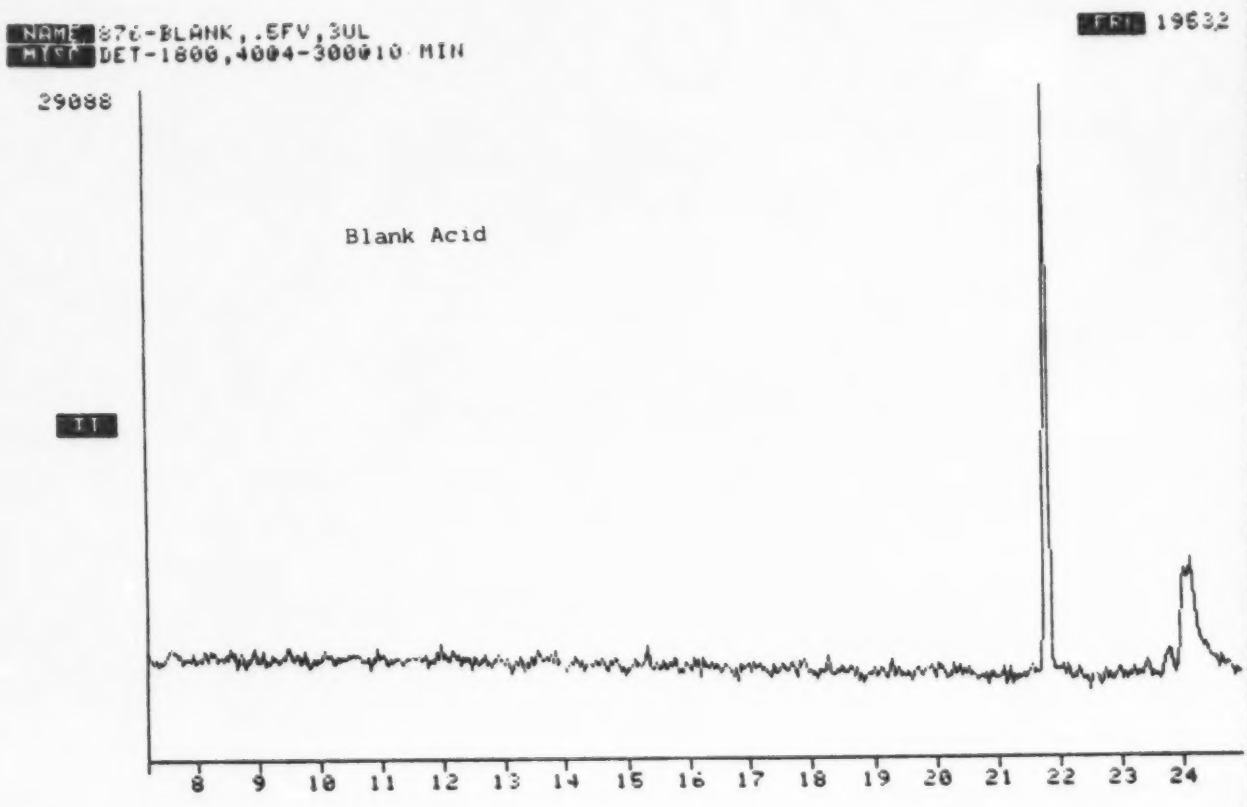
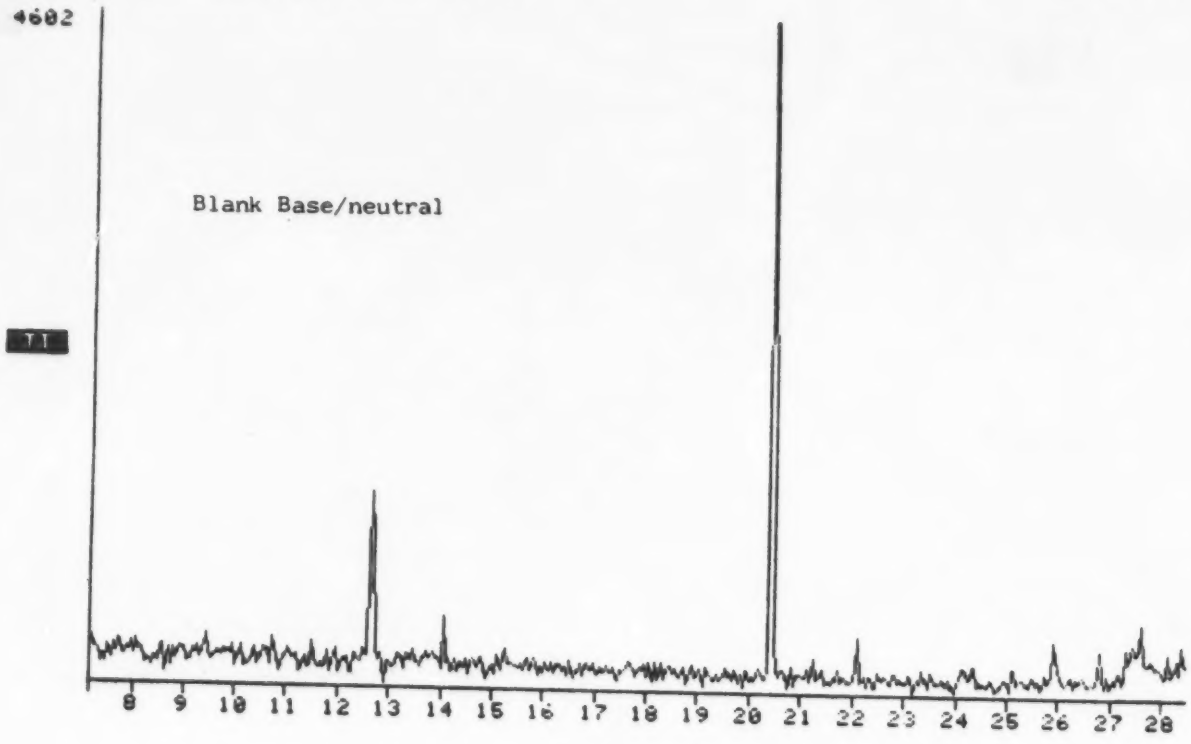
SAMPLE: 876-Blank

LAB SAMPLE #: 5-84-876-blank, acid fraction

CONCENTRATION: 0.02 ppm total extractable hydrocarbons, calculated against diesel

CLASS OF COMPOUNDS IDENTIFIED	APPROXIMATE CONCENTRATION (ppm)	(%)
see Chromatogram		

COMPOUND IDENTIFIED	CONFIDENCE LEVEL	CONCENTRATION (ppm)	COMMENTS


NAME 876-BLANK,.5FV,3UL
MTST DET-1800,4004-300010 MIN
FRI 19632
29088
Blank Acid
II
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

[redacted]:STD-BLK .5M:LFV 30L
[redacted]:DET-1800 4004-300010 MIN 18JUN84 [redacted]:MSN 19514